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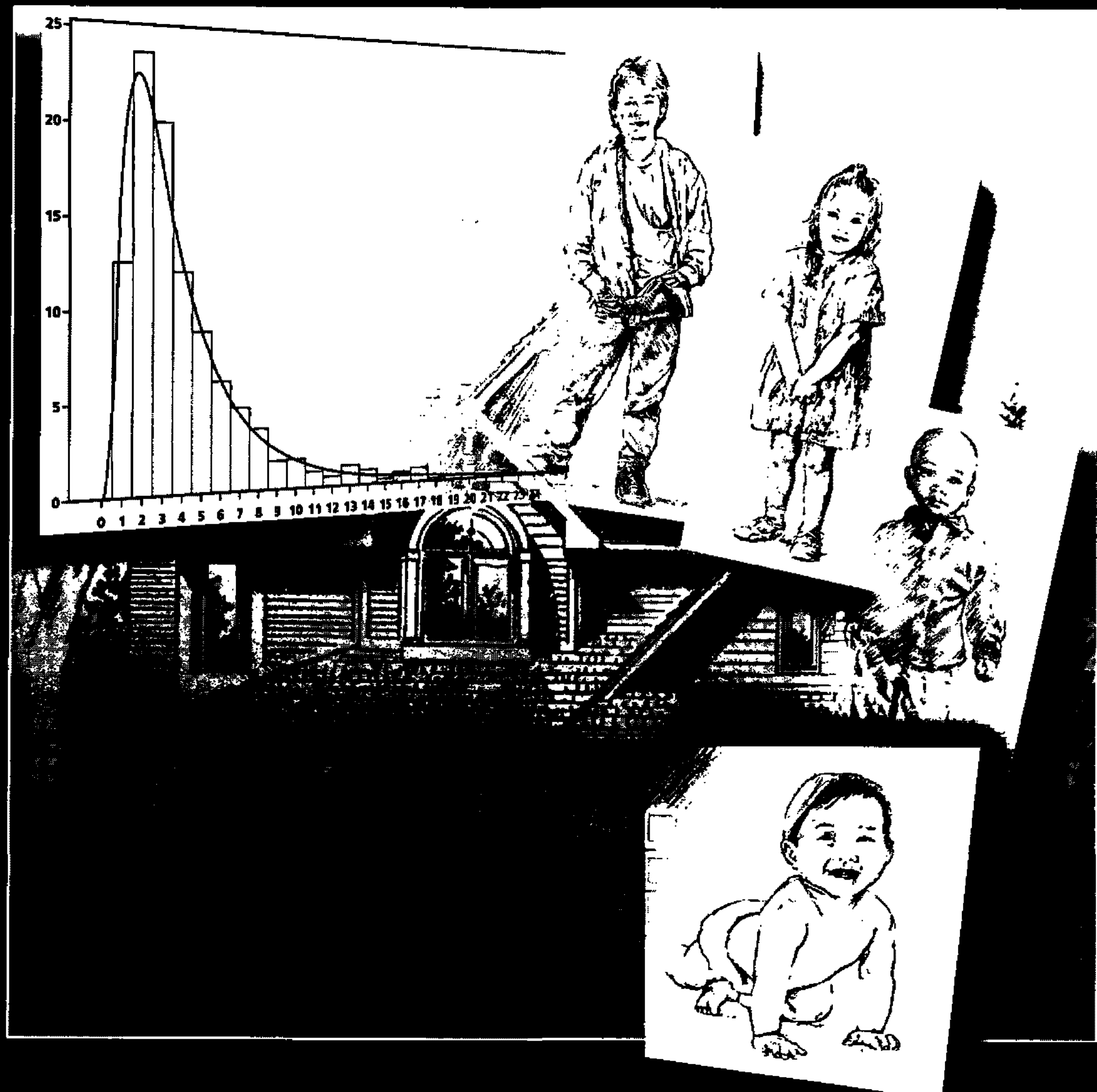
Risk Analysis to Support Standards for Lead in Paint, Dust, and Soil

Supplemental Report
VOLUME II: Appendices



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CONTRIBUTING ORGANIZATIONS

This report is a supplement to EPA 747-R-97-006 ("Risk Analysis to Support Standards for Lead in Paint, Dust, and Soil"). Efforts to produce this report were funded and managed by the U.S. Environmental Protection Agency. The risk analysis was conducted by Battelle Memorial Institute under contract to the U.S. Environmental Protection Agency. Each organization's responsibilities are listed below.

Battelle Memorial Institute (Battelle)

Battelle was responsible for performing the additional data analyses, literature reviews, and documentation presented in this report. Battelle was also responsible for preparing this report.

U.S. Environmental Protection Agency (EPA)

The Environmental Protection Agency was responsible for providing direction on the technical issues to be presented in this report, providing relevant information for the report, reviewing the report, contributing to the development of conclusions, and managing the peer review and publication of the report. The EPA Work Assignment Manager was Mr. Ronald Morony. The Deputy Work Assignment Managers were Mr. Brad Schultz and Mr. Dave Topping. The EPA Project Officer was Ms. Sineta Wooten.

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APPENDIX A

GLOSSARY FOR SECTION 2.1

<u>Sources:</u> The Concise Columbia Encyclopedia. 1995. Columbia University Press; Solomon et al. 1993. Biology, Third Edition. Harcourt Brace Publishing

astrocyte - a star-shaped cell, especially a neuroglial cell of nervous tissue.

axon - the long, tubular extension of the neuron that conducts nerve impulses away from the cell body.

blood-brain barrier - system of capillaries that regulates the movement of chemical substances, ions, and fluids in and out of the brain.

central nervous system - the portion of the vertebrate nervous system consisting of the brain and spinal cord.

cerebellum - the trilobed structure of the brain, lying posterior to the pons and medulla oblongata and inferior to the occipital lobes of the cerebral hemispheres, that is responsible for the regulation and coordination of complex voluntary muscular movement as well as the maintenance of posture and balance.

cerebral cortex - the extensive outer layer of gray matter of the cerebral hemispheres, largely responsible for higher brain functions, including sensation, voluntary muscle movement, thought, reasoning, and memory.

cerebrum - the large, rounded structure of the brain occupying most of the cranial cavity, divided into two cerebral hemispheres that are joined at the bottom by the corpus callosum. It controls and integrates motor, sensory, and higher mental functions, such as thought, reason, emotion, and memory.

cognitive development - various mental tasks and processes (e.g. receiving, processing, storing, and retrieving information) that mediate between stimulus and response and determine problem-solving ability.

demyelination - to destroy or remove the myelin sheath of (a nerve fiber), as through disease.

dendrite - a branched protoplasmic extension of a nerve cell that conducts impulses from adjacent cells inward toward the cell body.

EEG (electroencephalogram) - a graphic record of the electrical activity of the brain as recorded by an electroencephalograph. Also called *encephalogram*.

ECoG (electrocorticogram) - a graphic record of the electrical activity of the brain; used to calculate parameters of activity, such as wave amplitude and frequency.

encephalitis - inflammation of the brain.

encephalopathy - any of various diseases of the brain.

enzyme - any of numerous proteins or conjugated proteins produced by living organisms and functioning as biochemical catalysts.

gavage - introducing material directly into the stomach using a tube.

genotoxic - causing chromosomal/genetic aberrations.

glial cells (neuroglia) - the delicate network of branched cells and fibers that supports the tissue (neurons) of the central nervous system.

gray matter - brownish-gray nerve tissue, especially of the brain and spinal cord, composed of nerve cell bodies and their dendrites and some supportive tissue.

heme (hematin) - ferrous component of hemoglobin, as well as a functional group in other hemoproteins involved in various functions throughout the body.

hematological - science encompassing the medical study of the blood and blood-producing organs.

hepatic - of, relating to, or resembling the liver.

hippocampus - a ridge in the floor of each lateral ventricle of the brain that consists mainly of gray matter and has a central role in memory processes.

histopathology - the study of the microscopic anatomical changes in diseased tissue.

hormone - a chemical messenger, usually a peptide or steroid, produced by one tissue and conveyed by the bloodstream to another to effect physiological activity, such as growth or metabolism.

limbic system - a group of interconnected deep brain structures, common to all mammals, and involved in olfaction, emotion, motivation, behavior, and various autonomic functions.

microtubules - any of the proteinaceous cylindrical hollow structures that are distributed throughout the cytoplasm of eukaryotic cells, providing structural support and assisting in cellular locomotion and transport.

mitochondrion (plural mitochondria) - a spherical or elongated organelle in the cytoplasm of nearly all eukaryotic cells, containing genetic material and many enzymes important for cell metabolism, including those responsible for the conversion of food to usable energy.

morphology - the form and structure of an organism or one of its parts; without consideration of function.

mutagenic - inducing or increasing the frequency of mutation in an organism.

myelin sheath - the insulating envelope of myelin that surrounds the core of a nerve fiber or axon and facilitates the transmission of nerve impulses. In the peripheral nervous system, the sheath is formed from the cell membrane of the Schwann cell and, in the central nervous system, from oligodendrocytes. Also called *medullary sheath.*

necrosis - death of cells or tissues through injury or disease, especially in a localized area of the body.

nerve - many neurons bound together by connective tissue.

neuroglia - see *glial cells*.

neuron - cell specialized for the conduction of electrochemical nerve impulses that constitute the brain, spinal column, and nerves, consisting of a nucleated cell body with one or more dendrites and a single axon. Also called *nerve cell.*

neurotransmitter - a chemical substance that transmits information (nerve impulses) across the junction (synapse) that separates one nerve cell (neuron) from another nerve cell or a muscle. There are more than 300 known neurotransmitters, including dopamine and glutamine.

parasympathetic nervous system - the part of the autonomic nervous system originating in the brain stem and the lower part of the spinal cord that, in general, inhibits or opposes the physiological effects of the sympathetic nervous system, as in tending to stimulate digestive secretions, slow the heart, constrict the pupils, and dilate blood vessels.

peripheral nervous system - the part of the vertebrate nervous system constituting the nerves outside the central nervous system and including the cranial nerves, the spinal nerves, and the sympathetic and parasympathetic nervous systems.

perseveration - uncontrolled, incessantly repetitive behavior, occurring even when it directly results in rewards being withheld.

renal - of, relating to, or in the region of the kidneys.

somatosensory - of or relating to the perception of sensory stimuli from the skin and internal organs.

sympathetic nervous system - the part of the autonomic nervous system originating in the thoracic and lumbar regions of the spinal cord that in general inhibits or opposes the physiological effects of the parasympathetic nervous system, as in tending to reduce digestive secretions, speeding up the heart, and contracting blood vessels.

synapse - the junction across which a nerve impulse passes from an axon terminal to a neuron, a muscle cell, or a gland cell.

teratogenic - of, relating to, or causing malformations of an embryo or a fetus.

tubulin - a globular protein that is the basic structural constituent of microtubules.

APPENDIX B

CALCULATING AVERAGE IQ DECREMENT ASSUMING A NON-ZERO THRESHOLD ON THE IQ/BLOOD-LEAD CONCENTRATION RELATIONSHIP

This appendix is an update to Appendix E1 of the §403 risk analysis report, which provided details on how the health effect and blood-lead concentration endpoints are calculated given that blood-lead concentration is lognormally distributed with a geometric mean and geometric standard deviation specified by GM and GSD, respectively. In estimating average IQ decrement due to lead exposure and the percentages of children whose IQ decrement as a result of lead exposure was at or above 1, 2, or 3 points, the §403 risk analysis (as detailed in Appendix E1) assumed an average IQ decrement of 0.257 points for every 1.0 µg/dL increase in blood-lead concentration, and that no blood-lead threshold existed in this relationship (i.e., no non-zero blood-lead concentration existed below which the predicted IQ decrement was zero). To evaluate how the assumption of no threshold affects the estimates of these IQ decrement parameters, the sensitivity analyses presented within Chapters 5 and 6 of this document includes analyses that estimate these parameters under specified assumptions on a non-zero threshold (Sections 5.1.4 and 6.2.2). This appendix shows how these estimates were calculated in these sensitivity analyses (i.e., given a non-zero threshold). (Note that the assumption of a threshold does not affect how the probability of having a blood-lead concentration at or above a specified value or the probability of observing an IQ less than 70 due to lead exposure are calculated.)

P[IQ decrement ≥ x] for x=1, 2, 3

Let Y denote the IQ decrement associated with a blood-lead concentration specified by PbB. Assume that the non-zero blood-lead threshold in the blood-lead/IQ relationship is denoted by T. Then

$$Y = \begin{cases} 0.257*(PbB - T) & \text{when } PbB \geq T \\ 0 & \text{when } PbB < T. \end{cases}$$

Thus, for any positive value x, the probability of observing an IQ decrement (Y) at or above x is determined by the following:

$$P[Y \geq x] = P[0.257*(PbB-T) \geq x] = P[PbB \geq (x/0.257 + T)] = P[\ln(PbB) \geq \ln(x/0.257 + T)]$$

where ln(.) denotes the natural logarithm transformation. Then, since PbB is assumed to have a lognormal distribution,

$$P[\text{IQ decrement} \geq x] = 1 - \Phi\left(\frac{\ln\left(\frac{x}{0.257} + T\right) - \ln(GM)}{\ln(GSD)}\right)$$

where $\Phi(z)$ is the probability of observing a value less than z under the standard normal distribution.

Average IQ decrement

Under the same notation as in the previous paragraph, let f(x) denote the probability density function (PDF) of PbB (i.e., the PDF of a lognormal distribution), let F(x) denote the cumulative density function (CDF) of PbB (i.e., $F(x) = P[PbB \leq x]$), and let g(y) denote the PDF of Y. Then

$$
\begin{aligned}
g(y) &= (1/0.257)*f(y/0.257 + T) && \text{when } y > 0 \\
&= F(T) && \text{when } y = 0
\end{aligned}
$$

Then, the average IQ decrement, denoted by E[Y], is given by

$$E[Y] = \int_0^\infty y \cdot f(y/0.257 + T) \cdot (1/0.257) dy = [0.257 \int_T^\infty x \cdot f(x) dx] - [0.257 \cdot T \int_T^\infty f(x) dx]$$

This equates to the following:

$$
\begin{aligned}
\text{Avg. IQ decrement} = E[Y] = \\
& 0.257 \cdot GM \cdot \exp\left(\frac{\ln(GSD)^2}{2}\right) \cdot \left[1 - \Phi\left(\frac{\ln(T) - \ln(GM) - \ln(GSD)^2}{\ln(GSD)}\right)\right] \\
& - 0.257 \cdot \left[1 - \Phi\left(\frac{\ln(T) - \ln(GM)}{\ln(GSD)}\right)\right]
\end{aligned}
$$

Note that when T=0, average IQ decrement = $0.257*GM*\exp(\ln(GSD)^2/2)$, which is equation (4) specified within Appendix E1 of the §403 risk analysis report.

The standard deviation of the distribution of IQ decrement (Y) equals

$$\text{S.D.(IQ decrement)} = \sqrt{E(Y^2) - [E(Y)]^2}$$

The value of E[Y] is given above, and the value of $E(Y^2)$ can be found to equal

$$E[Y^2] = 0.257^2 \cdot \Big\{ \exp(2(\ln(GM) + \ln(GSD)^2)) \cdot \Big[1 - \Phi\Big(\frac{\ln(T) - \ln(GM)}{\ln(GSD)} - 2\ln(GSD)\Big)\Big]$$
$$- 2T \cdot \exp(\ln(GM) + \ln(GSD)^2 / 2)\Big[1 - \Phi\Big(\frac{\ln(T) - \ln(GSD)}{\ln(GSD)} - \ln(GSD)\Big)\Big]$$
$$+ T^2 \cdot \Big[1 - \Phi\Big(\frac{\ln(T) - \ln(GM)}{\ln(GSD)}\Big)\Big]\Big\}$$

APPENDIX C

METHOD TO IMPUTING HOUSEHOLD AVERAGE ENVIRONMENTAL-LEAD LEVELS FOR HOUSING UNITS IN THE NATIONAL SURVEY OF LEAD AND ALLERGENS IN HOUSING (NSLAH)

Method to Imputing Household Average Environmental-lead Levels for Housing Units in the National Survey of Lead and Allergens in Housing (NSLAH)

Occasionally, some of the 706 housing units included in the interim NSLAH database had no data available to calculate one or more of the following five environmental-lead parameters:

- area-weighted household average floor dust-lead loading
- area-weighted household average window sill dust-lead loading
- household average soil-lead concentration at dripline/entryway
- household average soil-lead concentration at mid-yard
- yard-wide average soil-lead concentration (taken to be the average of the previous two measures, or only one of these two measures if no data exist for the other).

In order to apply the risk analysis to the NSLAH data (specifically, the modeling analysis), it was necessary to estimate these parameters in situations where their values could not be calculated for a given housing unit due to a lack of available data (i.e., no floor dust-lead loading data, no window sill dust-lead loading data, or no soil-lead concentration data). Otherwise, those housing units having missing data, and the portion of the national housing stock represented by their sampling weights, could not be represented in the risk analysis. The method of assigning estimated data values to housing units having missing data is called *imputation*.

The imputation method applied to the interim NSLAH data was the same method used in the §403 risk analysis to impute environmental-lead levels for HUD National Survey units. This method was documented in Section 3.3.1.1 and Appendix C of the §403 risk analysis report. This method involved the following:

1. Each NSLAH housing unit was placed into one of 15 categories defined by the combination of five housing age categories (pre-1940, 1940-1959, 1960-1977, post-1977, unknown) and three categories determined by whether or not lead-based paint (LBP, defined as paint with an x-ray fluorescence measurement of at least 1.0 mg/cm^2) was observed in the unit (yes, no, unknown).

2. Within the eight categories in which both the housing age group and the presence of LBP were known, the weighted averages of the first four environmental-lead parameters above were calculated across the housing units having nonmissing data (where the weights corresponded to the interim NSLAH sampling weights). Then, within a given category, if a housing unit had missing data for one of these four parameters, the weighted average for that parameter was assigned to the unit.

3. For the category in which both the housing age group and the presence of LBP were unknown, housing units having missing data for a given parameter among the first four parameters above were assigned the weighted average for that

parameter calculated across all units in the interim NSLAH database having nonmissing data for that parameter.

4. For the four categories in which the housing age group was specified but the presence of LBP was unknown, housing units having missing data for a given parameter among the first four parameters above were assigned the weighted average for that parameter calculated across units within the same housing age group (without regard to the presence of LBP) that had nonmissing data for that parameter.

5. For the two categories in which the presence of LBP was known but the housing age group was not specified, housing units having missing data for a given parameter among the first four parameters above were assigned the weighted average for that parameter calculated across units having the same indicator of LBP (without regard to housing age group) that had nonmissing data for that parameter.

6. If a housing unit had a missing value for yard-wide average soil-lead concentration (i.e., no soil-lead concentration data for any soil samples), the parameter's imputed value assigned to this unit was the arithmetic average of the unit's imputed values for average dripline/entryway soil-lead concentration and average mid-yard soil-lead concentration. (Note that if soil-lead data existed for one location but not for the other, the unit's yard-wide average equaled the average for only the location having soil-lead data.)

Table C-1 presents the weighted averages that were assigned to units having missing data as part of this imputation scheme, according to category. Note that only those weighted averages that were assigned to at least one housing unit with missing data are displayed in this table. The numbers in parentheses correspond to the numbers of housing units in the category to which the given weighted average was assigned. Only 11 of the 15 housing unit categories are included in Table C-1, as no imputations were necessary in the other four categories.

As indicated in Table C-1, the above imputation procedure was applied twice to the NSLAH data: once when making no adjustments to not-detected values, and once after replacing not-detected values with one-half of the detection limit. Both of these scenarios were considered in the data summaries and risk analysis. In both cases, the imputed values were the same in a majority of situations, and those differences which did occur between the two cases were minor.

Table C-1. Imputed Environmental-Lead Measurements, by Housing Age Category and Presence of Lead-Based Paint (LBP)[1], and Numbers of Units in the Interim NSLAH to Which Imputed Measurements Were Assigned

Household Average Environmental-Lead Measurement	Imputed Measurement[2] (Number of Interim NSLAH units in which imputed measurements were assigned)										
	Pre-1940 Units		1940-1959 Units		1960-1977 Units		Post-1977 Units			Units with Housing Age Unspecified	
	LBP Present	LBP Not Present	LBP Present	LBP Not Present	LBP Present	LBP Not Present	LBP Present	LBP Not Present	LBP Presence Unknown	LBP Present	LBP Not Present
No Adjustment Made to Not-Detected Values											
Floor Dust-Lead Loading (µg/ft²)	35.30 (1)	--	4.94 (2)	--	--	1.24 (3)	--	1.18 (1)	1.20 (1)	21.20 (1)	--
Window Sill Dust-Lead Loading (µg/ft²)	449.06 (3)	15.45 (1)	144.42 (4)	94.66 (4)	--	28.95 (12)	28.81 (1)	13.99 (12)	15.62 (1)	285.64 (1)	32.73 (2)
Yard-Wide Average Soil-Lead Concentration[3] (µg/g)	710.77 (7)	176.71 (3)	276.07 (4)	242.58 (3)	161.91 (3)	52.33 (5)	--	24.85 (7)	27.78 (1)	392.05 (5)	63.84 (4)
Soil-Lead Concentration at Dripline/Entryway (µg/g)	1094.6 (8)	223.48 (5)	399.75 (6)	344.61 (3)	245.35 (3)	64.45 (8)	--	27.15 (8)	31.88 (1)	591.39 (5)	80.84 (4)
Soil-Lead Concentration at Mid-Yard (µg/g)	326.95 (8)	129.93 (3)	152.39 (7)	140.55 (3)	78.47 (4)	40.20 (8)	--	22.56 (11)	23.68 (1)	192.71 (5)	46.84 (5)
Not-Detected Values Replaced by LOD/2 (i.e., one-half of the detection limit)											
Floor Dust-Lead Loading (µg/ft²)	35.47 (1)	--	5.19 (2)	--	--	1.72 (3)	--	1.71 (1)	1.71 (1)	21.45 (1)	--
Window Sill Dust-Lead Loading (µg/ft²)	449.10 (3)	.15.81 (1)	144.76 (4)	94.88 (4)	--	29.28 (12)	28.90 (1)	14.43 (12)	16.02 (1)	285.81 (1)	33.09 (2)
Yard-Wide Average Soil-Lead Concentration (µg/g)	710.82 (7)	176.62 (3)	276.10 (4)	242.76 (3)	162.07 (3)	52.86 (5)	--	25.73 (7)	28.57 (1)	392.15 (5)	64.43 (4)
Soil-Lead Concentration at Dripline/Entryway (µg/g)	1094.6 (8)	223.48 (5)	399.76 (6)	344.66 (3)	245.47 (3)	64.85 (8)	--	27.86 (8)	32.52 (1)	591.46 (5)	81.30 (4)
Soil-Lead Concentration at Mid-Yard (µg/g)	327.01 (8)	129.75 (3)	152.45 (7)	140.86 (3)	78.67 (4)	40.87 (8)	--	23.60 (11)	24.63 (1)	192.84 (5)	47.56 (5)

[1] Units with lead-based paint have a maximum observed XRF reading of at least 1.0 mg/cm² on interior or exterior painted surfaces.
[2] See text for details on method of determining imputed measurements.
[3] Imputed only when unit has no soil-lead data for either dripline/entryway or mid-yard.

APPENDIX D1

SUMMARIES OF INTERIM DUST-LEAD LOADING DATA FROM THE NATIONAL SURVEY OF LEAD AND ALLERGENS IN HOUSING, (NSLAH), WHERE IMPUTED DATA ARE EXCLUDED

Summaries of Interim Dust-Lead Loading Data from the National Survey of Lead and Allergens in Housing (NSLAH), Where Imputed Data Are Excluded

This appendix presents descriptive statistics of average household dust-lead loadings for floors and window sills from the §403 risk analysis and from the interim NSLAH dust-lead loading data where imputed data values calculated based on the methods presented in Appendix C are omitted. These summaries complement the summary tables and boxplots presented in Tables 3-4 through 3-11b and Figures 3-1 through 3-6 in the main body of this report, which included imputed household averages for housing units having no dust-lead loading data.

The statistics on the interim NSLAH data are provided in this appendix under five different approaches to handling sample results that fall below the instrument's detection limit. As noted in Table 3-1, the interim NSLAH database reported dust-lead amounts as they were measured by the analytical instruments, regardless of whether these amounts were below the instrument's detection limit. While using these actual reported lead amounts rather than a censored result based on the detection limit can lead to more accurate portrayals of the actual lead amounts in the samples, some of these reported amounts are zero or below. This can cause problems in the risk analysis, as the empirical model takes natural logarithms of the household averages, and logarithms can only be taken on positive values. Therefore, the descriptive statistics of the interim NSLAH data are presented in this appendix under five approaches to handling not-detected values associated with individual sample analyses:

- No adjustment (i.e., using data as reported in the database)
- Replacing the value with zero
- Replacing the value with the detection limit (LOD) divided by two
- Replacing the value with the detection limit divided by the square root of two
- Replacing the value with the detection limit

Replacement with zero introduces the greatest amount of negative bias (i.e., underestimation), while replacement with the detection limit introduces the greatest amount of positive bias. The detection limit divided by the square root of two is an efficient estimator of the true amount when the data are lognormally distributed, while the detection limit divided by two is recommended when the distribution is highly skewed. Results are presented under these different approaches to illustrate the impact that any one approach has on the characterized distribution.

The following tables appearing in this appendix are associated with the specified tables in Chapter 3 of the report:

- Tables D1-1 and D1-2: national estimates complementing Tables 3-4 and 3-5

- Tables D1-3 and D1-4: estimates by housing age category, complementing Tables 3-6 and 3-7

- Tables D1-5 and D1-6: estimates by Census region, complementing Tables 3-8 and 3-9

- Tables D1-7a through D1-8b: estimates by combinations of Census region and housing age category, complementing Tables 3-10a through 3-11b.

The following boxplots appearing in this appendix are associated with the specified boxplots in Chapter 3 of the report:

- Figures D1-1 and D1-2: national estimates complementing Figures 3-1 and 3-2

- Figures D1-3 and D1-4: estimates by housing age category, complementing Figures 3-3 and 3-4

- Figures D1-5 and D1-6: estimates by Census region, complementing Figures 3-5 and 3-6.

While Tables D1-1 through D1-4 and Figures D1-1 through D1-2 contain interim NSLAH data summaries under all five approaches to handling not-detected values, the remaining tables and figures in this appendix present interim NSLAH data summaries only for the two approaches (no adjustment; replace by one-half of the level of detection) most likely to be used in the supplemental risk analysis and considered in the interim NSLAH data summaries presented in Chapter 3.

Table D1-1. Descriptive Statistics of Area-Weighted Average Floor Wipe Dust-Lead Loadings for Households, As Reported in the §403 Risk Analysis Versus the Interim NSLAH Data (imputed data omitted for the NSLAH)

Study	How Not-Detected and Negative Data were Handled	Area-Weighted Average Floor Dust-Lead Loading ($\mu g/ft^2$)[1]								
		# Surveyed Units with Positive Averages	Arithmetic Mean	Geometric Mean[2]	Geometric Std. Dev.[2]	Minimum	25th Percentile	Median	75th Percentile	Maximum
§403 Risk Analysis (HUD Natl. Survey)		284	16.5	6.27	3.49	0.508	2.65	5.32	12.2	375
Interim NSLAH	No adjustment	624	10.4	1.21	4.56	-1.23	0.300	1.03	2.30	5940
	Replaced by 0	417	10.1	1.95	3.89	0.00	0.00	0.500	2.00	5940
	Replaced by LOD/2	697	10.8	1.80	2.76	0.750	0.950	1.31	2.46	5950
	Replaced by LOD/√2	697	11.1	2.21	2.50	1.06	1.25	1.68	2.84	5950
	Replaced by LOD	697	11.4	2.73	2.29	1.50	1.60	2.10	3.20	5950

[1] All statistics are calculated by weighting each household by its sampling weight.
[2] Only household averages greater than zero are used to calculate this value (data for all units with floor dust-lead data are used to calculate the remaining statistics).

Table D1-2. Descriptive Statistics of Area-Weighted Average Window Sill Wipe Dust-Lead Loadings for Households, As Reported in the §403 Risk Analysis Versus the Interim NSLAH Data (imputed data omitted for the NSLAH)

Study	How Not-Detected and Negative Data were Handled	Area-Weighted Average Window Sill Dust-Lead Loading ($\mu g/ft^2$)[1]								
		# Surveyed Units with Positive Averages	Arith-metic Mean	Geo-metric Mean[2]	Geo-metric Std. Dev.[2]	Minimum	25th Percen-tile	Median	75th Percen-tile	Maximum
§403 Risk Analysis (HUD Natl. Survey)		284	550	23.0	15.8	0.0118	4.35	19.5	198	43700
Interim NSLAH	No adjustment	649	140	13.6	8.05	-9.43	2.71	11.0	50.3	11100
	Replaced by 0	563	139	20.2	6.72	0.00	1.94	10.8	50.1	11100
	Replaced by LOD/2	665	140	14.9	6.71	0.445	3.09	11.1	50.1	11100
	Replaced by LOD/√2	665	141	16.2	6.22	0.629	3.75	11.6	50.3	11100
	Replaced by LOD	665	141	17.6	5.77	0.889	4.39	12.1	50.3	11100

[1] All statistics are calculated by weighting each household by its sampling weight.
[2] Only household averages greater than zero are used to calculate this value (data for all units with window sill dust-lead data are used to calculate the remaining statistics).

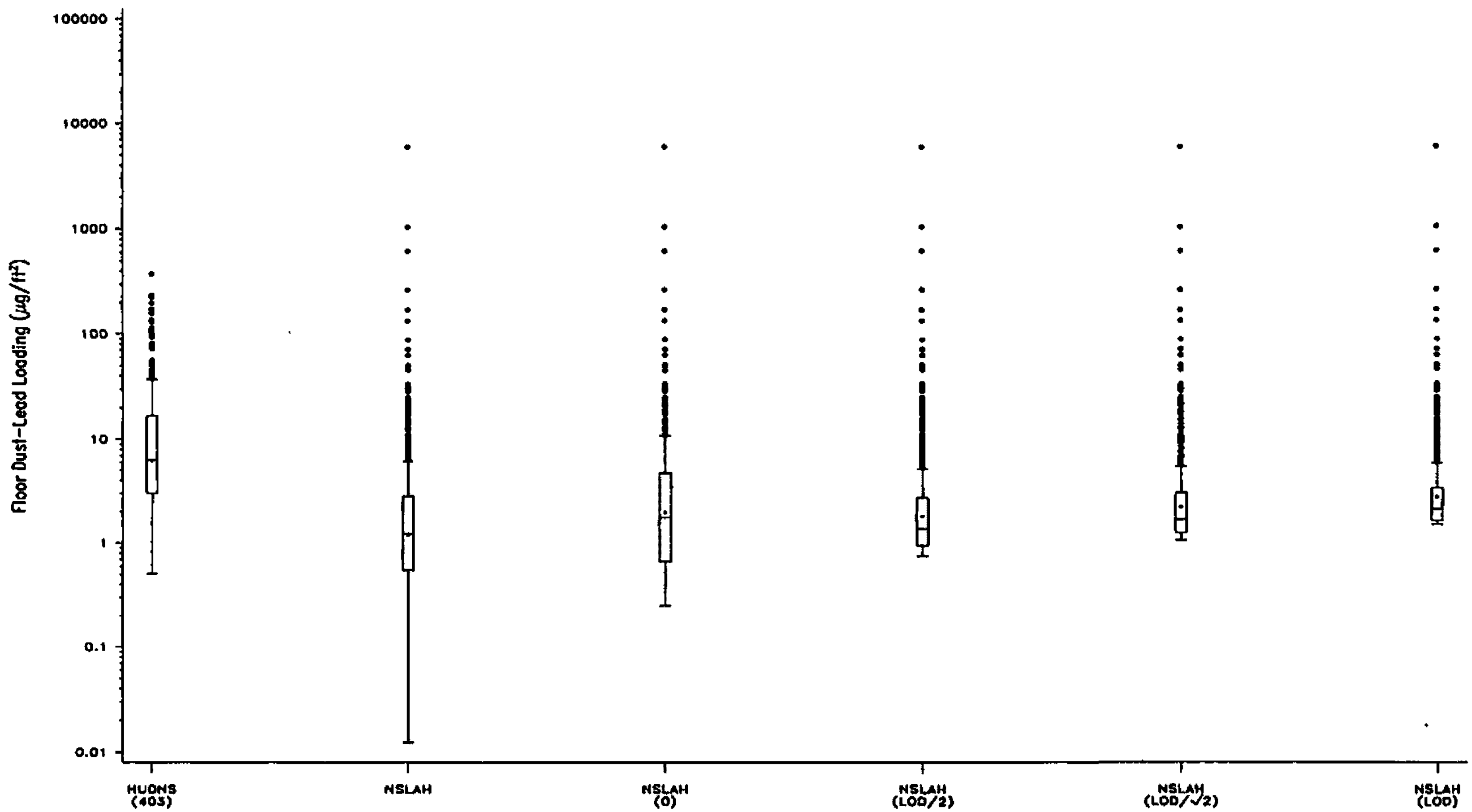

Figure D1-1. Boxplots of Area-Weighted Average Floor Wipe Dust-Lead Loadings (µg/ft²) As Observed in the §403 Risk Analysis (Using HUD National Survey Data) and in the NSLAH (under 5 approaches to handling not-detected values) (imputed data omitted for the NSLAH)

(Note: Dust-lead loadings from the HUD National Survey have been converted to wipe-equivalents in the §403 risk analysis using the methods documented in the §403 risk analysis report. See text for definitions of labels along the horizontal axis.)

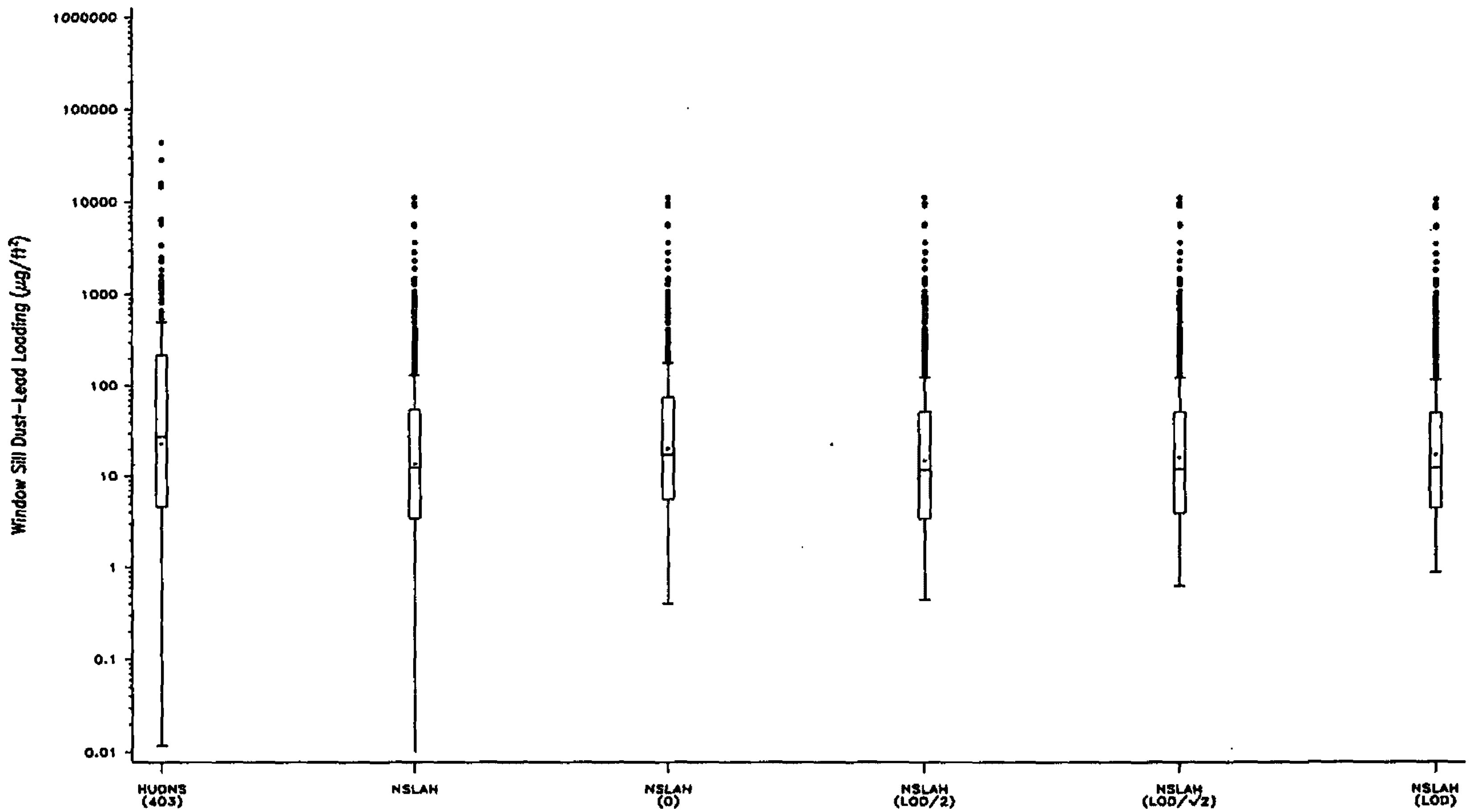

Figure D1-2. Boxplots of Area-Weighted Average Window Sill Wipe Dust-Lead Loadings (µg/ft²) As Observed in the §403 Risk Analysis (Using HUD National Survey Data) and in the NSLAH (under 5 approaches to handling not-detected values) (imputed data omitted for the NSLAH)

(Note: Dust-lead loadings from the HUD National Survey have been converted to wipe-equivalents in the §403 risk analysis using the methods documented in the §403 risk analysis report. See text for definitions of labels along the horizontal axis.)

Table D1-3. Descriptive Statistics of Area-Weighted Average Floor Wipe Dust-Lead Loadings for Households, Presented by Housing Age Category, As Reported in the §403 Risk Analysis Versus the Interim NSLAH Data (imputed data omitted for the NSLAH)

Study	How Not-Detected and Negative Data were Handled	Area-Weighted Average Floor Dust-Lead Loading (µg/ft²)[1]								
		# Units with Positive Averages	Arithmetic Mean	Geometric Mean[2]	Geometric Std. Dev.[2]	Minimum	25th Percentile	Median	75th Percentile	Maximum
Units Built Prior to 1940										
§403 Risk Analysis (HUD Natl. Survey)		77	47.9	22.6	3.63	0.991	8.84	17.7	79.7	375
Interim NSLAH	No adjustment	110	36.9	3.66	4.49	-0.600	1.30	2.42	9.25	5940
Interim NSLAH	Replaced by 0	97	36.6	4.12	4.64	0.00	0.750	2.20	9.25	5940
Interim NSLAH	Replaced by LOD/2	113	37.0	3.92	3.94	0.750	1.45	2.71	9.25	5950
Interim NSLAH	Replaced by LOD/√2	113	37.2	4.36	3.62	1.06	1.68	3.05	9.27	5950
Interim NSLAH	Replaced by LOD	113	37.5	4.89	3.34	1.50	2.00	3.40	9.38	5950
Units Built from 1940 - 1959										
§403 Risk Analysis (HUD Natl. Survey)		87	18.1	8.74	3.34	0.508	4.07	7.81	22.4	171
Interim NSLAH	No adjustment	132	4.10	1.88	3.58	-0.720	0.719	1.77	3.66	71.0
Interim NSLAH	Replaced by 0	96	3.75	2.38	3.33	0.00	0.00	1.40	3.40	71.0
Interim NSLAH	Replaced by LOD/2	143	4.37	2.29	2.64	0.750	1.05	1.98	3.55	71.0
Interim NSLAH	Replaced by LOD/√2	143	4.63	2.70	2.37	1.06	1.37	2.22	3.92	71.0
Interim NSLAH	Replaced by LOD	143	4.99	3.22	2.15	1.50	1.77	2.52	4.83	71.0
Units Built from 1960-1977 (1960 - 1979 for the §403 risk analysis)										
§403 Risk Analysis (HUD Natl. Survey)		120	6.74	4.14	2.45	0.657	2.25	3.62	7.59	106
Interim NSLAH	No adjustment	173	1.51	0.905	3.52	-0.733	0.206	0.880	1.70	28.5
Interim NSLAH	Replaced by 0	107	1.20	1.32	2.69	0.00	0.00	0.400	1.38	28.6
Interim NSLAH	Replaced by LOD/2	198	1.96	1.45	1.94	0.750	0.900	1.20	1.94	28.8
Interim NSLAH	Replaced by LOD/√2	198	2.28	1.83	1.76	1.06	1.24	1.53	2.19	28.8
Interim NSLAH	Replaced by LOD	198	2.73	2.32	1.63	1.50	1.60	1.98	2.76	28.9

Table D1-3. (cont.)

Study	How Not-Detected and Negative Data were Handled	Area-Weighted Average Floor Dust-Lead Loading ($\mu g/ft^2$)[1]								
		# Units with Positive Averages	Arith-metic Mean	Geo-metric Mean[2]	Geo-metric Std. Dev.[2]	Minimum	25th Percen-tile	Median	75th Percen-tile	Maximum
Units Built After 1977 (after 1979 for the §403 risk analysis)										
§403 Risk Analysis (HUD Natl. Survey)		28	4.16	3.14	2.06	1.06	1.76	2.84	5.66	12.9
Interim NSLAH	No adjustment	149	1.20	0.542	3.35	-1.05	0.146	0.400	1.07	265
Interim NSLAH	Replaced by 0	72	0.949	0.959	2.53	0.00	0.00	0.00	0.500	265
Interim NSLAH	Replaced by LOD/2	178	1.71	1.14	1.72	0.750	0.750	1.00	1.35	265
Interim NSLAH	Replaced by LOD/√2	178	2.03	1.49	1.59	1.06	1.06	1.34	1.72	265
Interim NSLAH	Replaced by LOD	178	2.47	1.96	1.50	1.50	1.50	1.70	2.25	265
NSLAH Units with Unspecified Year-Built Indicator										
Interim NSLAH	No adjustment	60	31.9	1.30	6.49	-1.23	0.300	1.24	2.50	1040
Interim NSLAH	Replaced by 0	45	31.7	2.17	5.44	0.00	0.00	0.660	2.20	1040
Interim NSLAH	Replaced by LOD/2	65	32.3	2.11	3.82	0.750	1.00	1.40	2.53	1040
Interim NSLAH	Replaced by LOD/√2	65	32.6	2.53	3.51	1.06	1.38	1.84	2.75	1040
Interim NSLAH	Replaced by LOD	65	32.9	3.08	3.24	1.50	1.70	2.22	3.10	1040

[1] All statistics are calculated by weighting each household by its sampling weight.
[2] Only household averages greater than zero are used to calculate this value (data for all units with floor dust-lead data are used to calculate the remaining statistics).

Table D1-4. Descriptive Statistics of Area-Weighted Average Window Sill Wipe Dust-Lead Loadings for Households, Presented by Housing Age Category, As Reported in the §403 Risk Analysis Versus the Interim NSLAH Data (imputed data omitted for the NSLAH)

Study	How Not-Detected and Negative Data were Handled	Area-Weighted Average Window Sill Dust-Lead Loading ($\mu g/ft^2$)[1]								
		# Units with Positive Averages	Arithmetic Mean	Geometric Mean[2]	Geometric Std. Dev.[2]	Minimum	25th Percentile	Median	75th Percentile	Maximum
Units Built Prior to 1940										
§403 Risk Analysis (HUD Natl. Survey)		77	2060	168	16.7	0.0155	35.6	198	1220	43700
Interim NSLAH	No adjustment	109	400	72.9	6.62	-0.152	21.1	78.2	284	11100
Interim NSLAH	Replaced by 0	107	400	76.3	6.35	0.00	21.1	78.2	284	11100
Interim NSLAH	Replaced by LOD/2	110	400	72.2	6.47	1.03	21.1	78.2	284	11100
Interim NSLAH	Replaced by LOD/√2	110	400	73.3	6.30	1.46	21.1	78.2	284	11100
Interim NSLAH	Replaced by LOD	110	400	74.7	6.12	2.06	21.1	78.2	284	11100
Units Built from 1940 - 1959										
§403 Risk Analysis (HUD Natl. Survey)		87	285	22.0	10.7	0.0118	6.47	19.1	107	16100
Interim NSLAH	No adjustment	136	130	22.7	6.91	-1.73	6.35	21.0	69.1	3630
Interim NSLAH	Replaced by 0	122	129	30.3	5.90	0.00	5.53	19.5	68.4	3630
Interim NSLAH	Replaced by LOD/2	137	130	24.2	6.04	0.923	6.10	21.5	69.6	3630
Interim NSLAH	Replaced by LOD/√2	137	130	25.7	5.64	1.31	6.48	21.7	70.1	3630
Interim NSLAH	Replaced by LOD	137	131	27.5	5.27	1.66	7.56	21.9	70.9	3630
Units Built from 1960-1977 (1960 - 1979 for the §403 risk analysis)										
§403 Risk Analysis (HUD Natl. Survey)		120	184	16.2	14.6	0.0164	2.05	16.6	217	5790
Interim NSLAH	No adjustment	183	37.3	9.78	4.89	-2.32	2.82	8.03	25.4	1390
Interim NSLAH	Replaced by 0	163	36.3	12.1	4.47	0.00	2.07	6.95	21.5	1390
Interim NSLAH	Replaced by LOD/2	189	37.6	10.4	4.31	1.02	3.06	7.86	26.4	1390
Interim NSLAH	Replaced by LOD/√2	189	38.1	11.2	4.05	1.36	3.60	8.29	26.5	1390
Interim NSLAH	Replaced by LOD	189	38.8	12.3	3.82	1.47	4.20	8.83	27.5	1390

Table D1-4. (cont.)

Study	How Not-Detected and Negative Data were Handled	Area-Weighted Average Window Sill Dust-Lead Loading (µg/ft²)[1]								
		# Units with Positive Averages	Arith-metic Mean	Geo-metric Mean[2]	Geo-metric Std. Dev.[2]	Minimum	25th Percen-tile	Median	75th Percen-tile	Maximum
Units Built After 1977 (after 1979 for the §403 risk analysis)										
§403 Risk Analysis (HUD Natl. Survey)		28	83.0	8.17	9.94	0.0164	2.58	8.11	57.8	1590
Interim NSLAH	No adjustment	160	15.6	3.26	5.32	-9.43	0.916	2.80	8.17	426
	Replaced by 0	115	14.8	5.40	4.38	0.00	0.00	1.71	7.29	409
	Replaced by LOD/2	166	16.0	4.25	3.80	0.445	1.69	3.33	8.50	427
	Replaced by LOD/√2	166	16.5	4.95	3.50	0.629	2.07	4.01	9.48	434
	Replaced by LOD	166	17.3	5.83	3.25	0.889	2.61	4.80	10.0	445
NSLAH Units with Unspecified Year-Built Indicator										
Interim NSLAH	No adjustment	61	379	38.5	7.55	-0.629	14.3	36.4	116	9030
	Replaced by 0	56	379	54.2	5.45	0.00	14.3	36.4	116	9030
	Replaced by LOD/2	63	379	38.9	6.91	0.720	17.7	36.4	116	9030
	Replaced by LOD/√2	63	379	40.4	6.53	1.02	18.8	36.4	116	9030
	Replaced by LOD	63	380	42.1	6.19	1.44	18.8	36.4	116	9030

[1] All statistics are calculated by weighting each household by its sampling weight.
[2] Only household averages greater than zero are used to calculate this value (data for all units with window sill dust-lead data are used to calculate the remaining statistics).

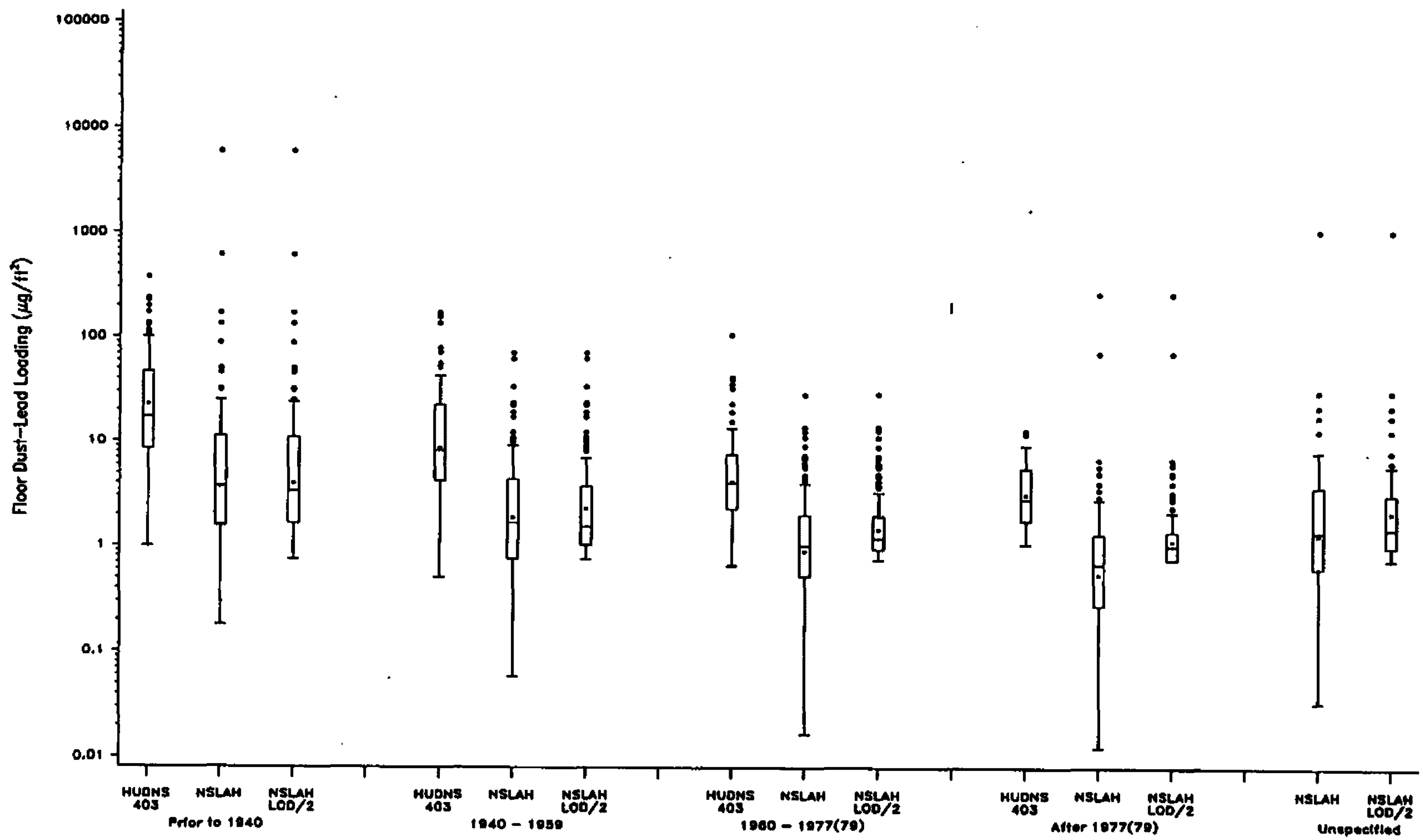

Figure D1-3. Boxplots of Area-Weighted Average Floor Wipe Dust-Lead Loadings (μg/ft²), by Housing Age Category, As Observed in the §403 Risk Analysis (Using HUD National Survey Data) and in the NSLAH (under 2 approaches to handling not-detected values) (imputed data omitted for the NSLAH)

(Note: Dust-lead loadings from the HUD National Survey have been converted to wipe-equivalents in the §403 risk analysis using the methods documented in the §403 risk analysis report. See text for definitions of labels along the horizontal axis.)

Table D1-5. Descriptive Statistics of Area-Weighted Average Floor Wipe Dust-Lead Loadings for Households, Presented by Census Region, As Reported in the §403 Risk Analysis Versus the Interim NSLAH Data (imputed data omitted for the NSLAH)

Study	How Not-Detected and Negative Data were Handled	Area-Weighted Average Floor Dust-Lead Loading ($\mu g/ft^2$)[1]								
		# Surveyed Units with Positive Averages	Arithmetic Mean	Geometric Mean[2]	Geometric Std. Dev.[2]	Minimum	25th Percentile	Median	75th Percentile	Maximum
Northeast										
§403 Risk Analysis (HUD Natl. Survey)		53	35.6	14.9	3.95	0.632	4.79	11.0	76.3	375
Interim NSLAH	No adjustment	103	10.0	2.28	4.42	-0.620	0.800	1.90	6.00	617
Interim NSLAH	Replaced by LOD/2	109	10.3	2.90	3.15	0.750	1.20	2.13	6.00	617
Midwest										
§403 Risk Analysis (HUD Natl. Survey)		73	14.7	6.32	3.26	0.508	2.83	6.32	11.0	173
Interim NSLAH	No adjustment	135	14.6	1.31	5.74	-0.733	0.283	1.16	2.48	1040
Interim NSLAH	Replaced by LOD/2	149	14.9	2.00	3.34	0.750	0.760	1.29	3.15	1040
South										
§403 Risk Analysis (HUD Natl. Survey)		134	13.3	5.01	3.28	0.735	2.00	3.89	10.0	236
Interim NSLAH	No adjustment	230	2.58	0.962	3.92	-1.05	0.253	0.900	1.76	265
Interim NSLAH	Replaced by LOD/2	260	3.00	1.53	2.22	0.750	0.970	1.20	1.89	265
West										
§403 Risk Analysis (HUD Natl. Survey)		52	9.81	4.97	2.75	1.06	2.65	4.01	8.43	197
Interim NSLAH	No adjustment	156	19.0	0.927	3.68	-1.23	0.250	0.760	1.62	5940
Interim NSLAH	Replaced by LOD/2	179	19.5	1.44	2.31	0.750	0.780	1.20	1.88	5950

[1] All statistics are calculated by weighting each household by its sampling weight.

[2] Only household averages greater than zero are used to calculate this value (data for all units with floor dust-lead data are used to calculate the remaining statistics).

Table D1-6. Descriptive Statistics of Area-Weighted Average Window Sill Wipe Dust-Lead Loadings for Households, Presented by Census Region, As Reported in the §403 Risk Analysis Versus the Interim NSLAH Data (imputed data omitted for the NSLAH)

Study	How Not-Detected and Negative Data were Handled	Area-Weighted Average Window Sill Dust-Lead Loading (µg/ft²)[1]								
		# Surveyed Units with Positive Averages	Arithmetic Mean	Geometric Mean[2]	Geometric Std. Dev.[2]	Minimum	25th Percentile	Median	75th Percentile	Maximum
Northeast										
§403 Risk Analysis (HUD Natl. Survey)		53	1440	92.2	16.1	0.0155	15.3	173	335	14600
Interim NSLAH	No adjustment	106	170	21.0	7.93	-1.89	5.94	14.6	89.5	5530
Interim NSLAH	Replaced by LOD/2	108	170	22.1	6.99	0.578	5.94	14.8	90.0	5530
Midwest										
§403 Risk Analysis (HUD Natl. Survey)		73	564	48.5	13.2	0.0706	7.76	83.0	309	43700
Interim NSLAH	No adjustment	143	216	19.9	7.13	-2.32	4.00	16.0	54.9	9630
Interim NSLAH	Replaced by LOD/2	148	216	20.5	6.37	1.12	4.67	15.7	56.1	9630
South										
§403 Risk Analysis (HUD Natl. Survey)		134	432	19.6	12.4	0.118	4.60	15.0	127	28400
Interim NSLAH	No adjustment	231	121	12.4	8.68	-9.43	2.33	10.2	53.8	11100
Interim NSLAH	Replaced by LOD/2	237	121	14.2	6.77	0.646	2.88	10.3	53.8	11100
West										
§403 Risk Analysis (HUD Natl. Survey)		52	62.2	4.45	12.7	0.0118	1.68	5.40	28.0	1400
Interim NSLAH	No adjustment	169	55.3	6.96	6.80	-0.115	1.74	6.08	25.6	3630
Interim NSLAH	Replaced by LOD/2	172	55.3	7.93	5.68	0.445	2.18	6.26	25.5	3630

[1] All statistics are calculated by weighting each household by its sampling weight.
[2] Only household averages greater than zero are used to calculate this value (data for all units with window sill dust-lead data are used to calculate the remaining statistics).

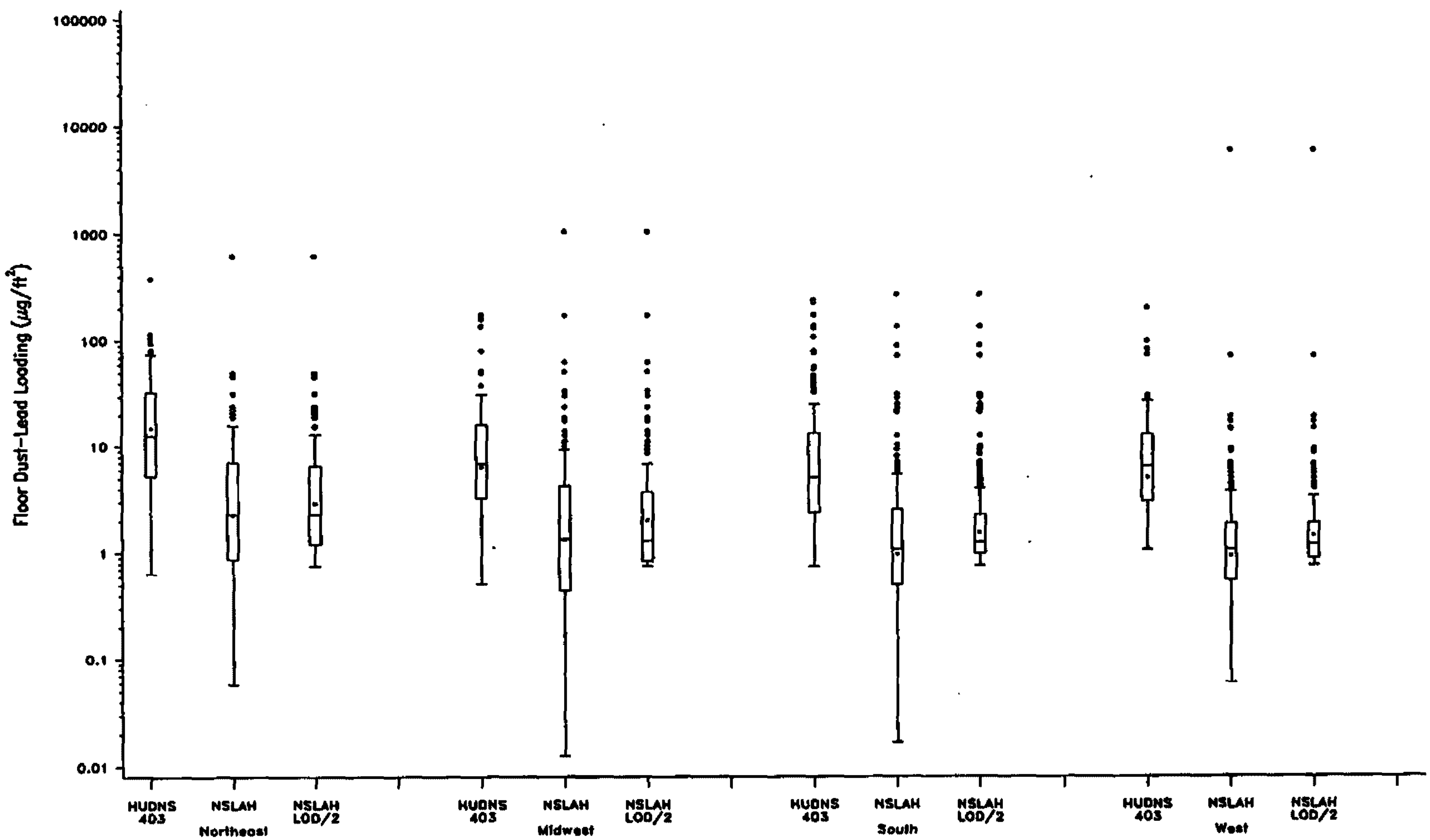

Figure D1-5. Boxplots of Area-Weighted Average Floor Wipe Dust-Lead Loadings (µg/ft²), by Census Region, Observed in the §403 Risk Analysis (Using HUD National Survey Data) and in the NSLAH (under 2 approaches to handling not-detected values) (imputed data omitted for the NSLAH)

(Note: Dust-lead loadings from the HUD National Survey have been converted to wipe-equivalents in the §403 risk analysis using the methods documented in the §403 risk analysis report. See text for definitions of labels along the horizontal axis.)

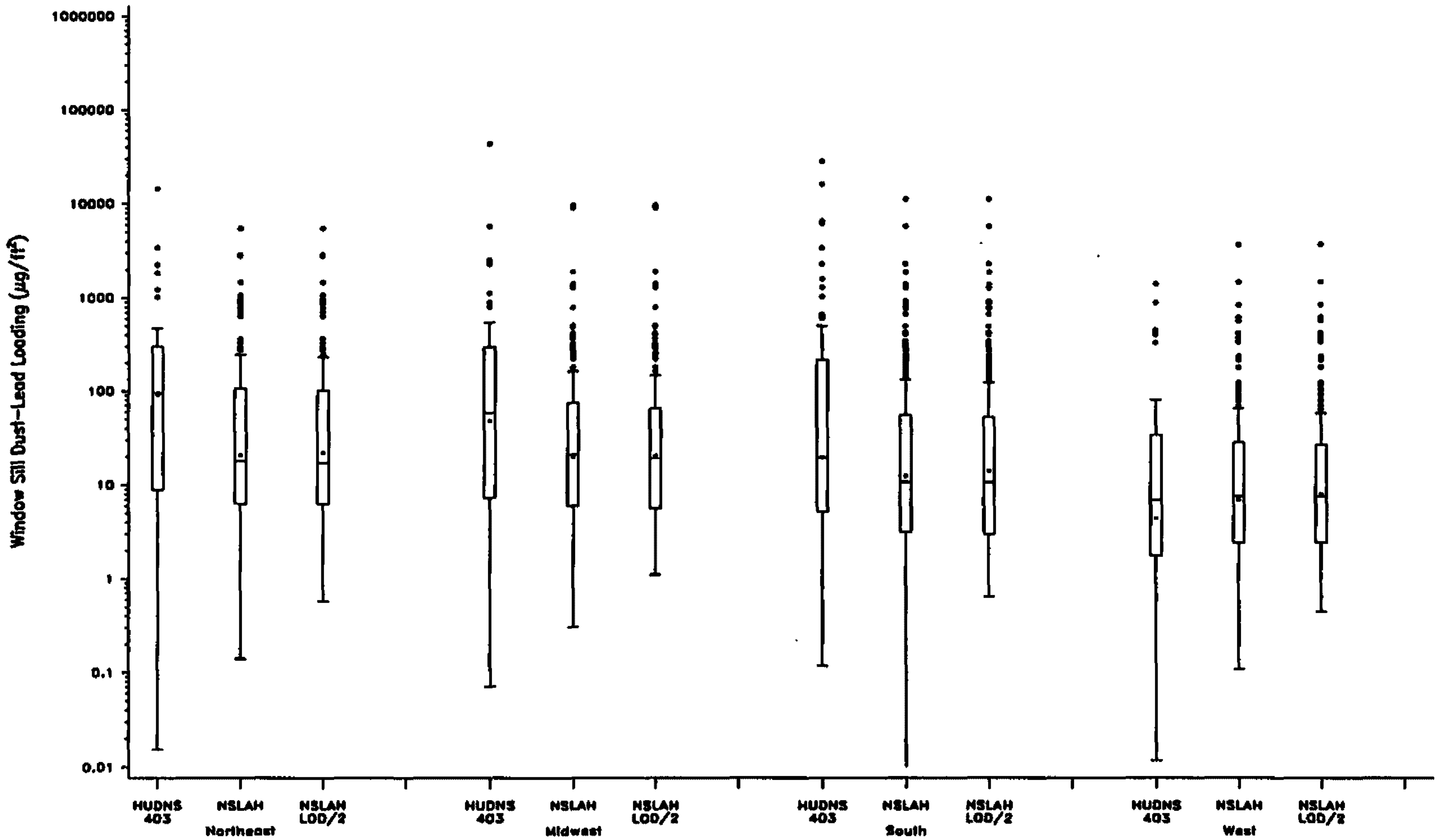

Figure D1-6. Boxplots of Area-Weighted Average Window Sill Wipe Dust-Lead Loadings (µg/ft²), by Census Region, As Observed in the §403 Risk Analysis (Using HUD National Survey Data) and in the NSLAH (under 2 approaches to handling not-detected values) (imputed data omitted for the NSLAH)

(Note: Dust-lead loadings from the HUD National Survey have been converted to wipe-equivalents in the §403 risk analysis using the methods documented in the §403 risk analysis report. See text for definitions of labels along the horizontal axis.)

Table D1-7a. Descriptive Statistics of Area-Weighted Average Floor Wipe Dust-Lead Loadings for Households, Presented by Housing Age and Census Region, As Reported in the §403 Risk Analysis Versus the Interim NSLAH Data Where No Adjustments Were Made to Not-Detected Results (imputed data omitted for the NSLAH)

Census Region	Study	Housing Age Category	Area-Weighted Average Floor Dust-Lead Loading ($\mu g/ft^2$)				
			# Surveyed Units	Arithmetic Mean	Geometric Mean	Geometric Std. Dev.	Median
Northeast	§403 Risk Anal.	Prior to 1940	26	63.5	36.5	3.39	76.3
	Interim NSLAH		41	23.7	5.02	4.31	4.20
	§403 Risk Anal.	1940 - 1959	17	13.2	8.84	2.54	7.81
	Interim NSLAH		21	3.75	2.37	3.36	2.38
	§403 Risk Anal.	1960 -1977 (1960-79 for §403)	10	7.00	4.73	2.23	4.76
	Interim NSLAH		19	3.34	1.72	3.76	1.46
	Interim NSLAH	After 1977	15	1.12	0.714	2.78	0.867
Midwest	§403 Risk Anal.	Prior to 1940	19	31.3	14.7	3.01	8.94
	Interim NSLAH		32	7.78	2.42	4.26	1.97
	§403 Risk Anal.	1940 - 1959	21	15.8	6.69	3.95	5.79
	Interim NSLAH		35	5.48	2.05	4.16	1.59
	§403 Risk Anal.	1960 -1977 (1960-79 for §403)	29	6.33	4.58	2.35	4.44
	Interim NSLAH		32	1.52	0.737	4.77	1.12
	§403 Risk Anal.	After 1977 (1979 for §403)	4	3.32	2.77	1.83	2.80
	Interim NSLAH		25	0.913	0.545	3.86	0.320
South	§403 Risk Anal.	Prior to 1940	19	50.7	20.8	4.01	19.0
	Interim NSLAH		26	11.0	3.66	3.93	2.74
	§403 Risk Anal.	1940 - 1959	33	25.4	10.3	3.91	10.0
	Interim NSLAH		42	3.66	1.63	3.40	1.77
	§403 Risk Anal.	1960 -1977 (1960-79 for §403)	64	8.06	4.13	2.74	3.39
	Interim NSLAH		69	1.16	0.814	3.09	0.880
	§403 Risk Anal.	After 1977 (1979 for §403)	18	4.19	3.16	2.05	2.84
	Interim NSLAH		70	1.04	0.543	3.13	0.480
West	§403 Risk Anal.	Prior to 1940	13	34.9	16.2	3.51	17.2
	Interim NSLAH		11	264	3.84	6.17	2.30
	§403 Risk Anal.	1940 - 1959	16	14.6	9.04	2.46	7.47
	Interim NSLAH		34	2.73	1.59	2.91	1.24
	§403 Risk Anal.	1960 -1977 (1960-79 for §403)	17	4.50	3.53	2.03	3.35
	Interim NSLAH		53	1.16	0.937	2.46	0.880
	§403 Risk Anal.	After 1977 (1979 for §403)	6	4.60	3.36	2.21	3.00
	Interim NSLAH		39	1.75	0.454	3.67	0.270

Table D1-7b. Descriptive Statistics of Area-Weighted Average Floor Wipe Dust-Lead Loadings for Households, Presented by Housing Age and Census Region, As Reported in the §403 Risk Analysis Versus the Interim NSLAH Data Where Not-Detected Results Were Replaced by LOD/2 (imputed data omitted for the NSLAH)

Census Region	Study	Housing Age Category	Area-Weighted Average Floor Dust-Lead Loading (µg/ft²)				
			# Surveyed Units	Arithmetic Mean	Geometric Mean	Geometric Std. Dev.	Median
Northeast	§403 Risk Anal.	Prior to 1940	26	63.5	36.5	3.39	76.3
	Interim NSLAH		41	23.8	5.47	3.91	4.35
	§403 Risk Anal.	1940 - 1959	17	13.2	8.84	2.54	7.81
	Interim NSLAH		23	4.03	2.86	2.23	2.40
	§403 Risk Anal.	1960 -1977 (1960-79 for §403)	10	7.00	4.73	2.23	4.76
	Interim NSLAH		21	3.58	2.16	2.60	1.68
	Interim NSLAH	After 1977	16	1.68	1.43	1.72	1.29
Midwest	§403 Risk Anal.	Prior to 1940	19	31.3	14.7	3.01	8.94
	Interim NSLAH		35	8.09	2.70	3.23	2.19
	§403 Risk Anal.	1940 - 1959	21	15.8	6.69	3.95	5.79
	Interim NSLAH		36	5.80	2.57	3.20	1.53
	§403 Risk Anal.	1960 -1977 (1960-79 for §403)	29	6.33	4.58	2.35	4.44
	Interim NSLAH		37	2.00	1.50	2.03	1.20
	§403 Risk Anal.	After 1977 (1979 for §403)	4	3.32	2.77	1.83	2.80
	Interim NSLAH		30	1.31	1.09	1.67	0.938
South	§403 Risk Anal.	Prior to 1940	19	50.7	20.8	4.01	19.0
	Interim NSLAH		26	11.1	3.87	3.76	2.70
	§403 Risk Anal.	1940 - 1959	33	25.4	10.3	3.91	10.0
	Interim NSLAH		48	3.94	1.99	2.35	1.54
	§403 Risk Anal.	1960 -1977 (1960-79 for §403)	64	8.06	4.13	2.74	3.39
	Interim NSLAH		79	1.67	1.30	1.74	1.16
	§403 Risk Anal.	After 1977 (1979 for §403)	18	4.19	3.16	2.05	2.84
	Interim NSLAH		82	1.54	1.13	1.57	1.06
West	§403 Risk Anal.	Prior to 1940	13	34.9	16.2	3.51	17.2
	Interim NSLAH		11	264	4.03	5.91	2.19
	§403 Risk Anal.	1940 - 1959	16	14.6	9.04	2.46	7.47
	Interim NSLAH		36	2.94	1.88	2.32	1.38
	§403 Risk Anal.	1960 -1977 (1960-79 for §403)	17	4.50	3.53	2.03	3.35
	Interim NSLAH		61	1.62	1.39	1.66	1.26
	§403 Risk Anal.	After 1977 (1979 for §403)	6	4.60	3.36	2.21	3.00
	Interim NSLAH		50	2.34	1.07	1.95	0.900

Table D1-8a. Descriptive Statistics of Area-Weighted Average Window Sill Wipe Dust-Lead Loadings for Households, Presented by Housing Age and Census Region, As Reported in the §403 Risk Analysis Versus the Interim NSLAH Data Where No Adjustments Were Made to Not-Detected Results (imputed data omitted for the NSLAH)

Census Region	Study	Housing Age Category	Area-Weighted Average Window Sill Dust-Lead Loading (µg/ft²)				
			# Surveyed Units	Arithmetic Mean	Geometric Mean	Geometric Std. Dev.	Median
Northeast	§403 Risk Anal.	Prior to 1940	26	2700	265	15.8	176
	Interim NSLAH		39	395	95.9	6.37	91.7
	§403 Risk Anal.	1940 - 1959	17	98.5	32.6	5.55	50.7
	Interim NSLAH		23	62.7	20.1	4.31	18.5
	§403 Risk Anal.	1960 -1977 (1960-79 for §403)	10	499	38.9	20.8	217
	Interim NSLAH		20	13.9	7.88	2.67	6.49
	Interim NSLAH	After 1977	16	18.3	3.28	5.69	2.06
Midwest	§403 Risk Anal.	Prior to 1940	19	1660	435	5.79	542
	Interim NSLAH		35	355	64.3	6.13	60.1
	§403 Risk Anal.	1940 - 1959	21	98.2	17.7	11.6	17.4
	Interim NSLAH		34	103	18.9	6.38	16.0
	§403 Risk Anal.	1960 -1977 (1960-79 for §403)	29	223	20.9	11.6	48.3
	Interim NSLAH		33	27.9	9.94	4.75	9.54
	§403 Risk Anal.	After 1977 (1979 for §403)	4	62.5	27.5	6.78	83.0
	Interim NSLAH		30	21.0	6.57	3.64	5.86
South	§403 Risk Anal.	Prior to 1940	19	2450	64.0	23.1	24.4
	Interim NSLAH		25	606	105	5.95	115
	§403 Risk Anal.	1940 - 1959	33	657	38.9	9.93	26.2
	Interim NSLAH		43	164	27.1	9.13	27.3
	§403 Risk Anal.	1960 -1977 (1960-79 for §403)	64	149	24.0	12.6	32.0
	Interim NSLAH		73	59.1	12.9	5.98	10.3
	§403 Risk Anal.	After 1977 (1979 for §403)	18	112	9.09	8.60	7.58
	Interim NSLAH		68	18.4	3.37	6.20	3.62
West	§403 Risk Anal.	Prior to 1940	13	125	11.5	14.7	7.05
	Interim NSLAH		10	49.5	14.2	5.44	17.1
	§403 Risk Anal.	1940 - 1959	16	107	7.35	13.2	6.96
	Interim NSLAH		36	188	26.3	7.34	33.4
	§403 Risk Anal.	1960 -1977 (1960-79 for §403)	17	58.7	3.83	11.5	4.35
	Interim NSLAH		57	25.7	7.00	4.25	4.74
	§403 Risk Anal.	After 1977 (1979 for §403)	6	9.66	2.65	11.6	5.94
	Interim NSLAH		46	5.21	1.79	3.92	1.39

Table D1-8b. Descriptive Statistics of Area-Weighted Average Window Sill Wipe Dust-Lead Loadings for Households, Presented by Housing Age and Census Region, As Reported in the §403 Risk Analysis Versus the Interim NSLAH Data Where Not-Detected Results Were Replaced by LOD/2 (imputed data omitted for the NSLAH)

Census Region	Study	Housing Age Category	Area-Weighted Average Window Sill Dust-Lead Loading (µg/ft²)				
			# Surveyed Units	Arithmetic Mean	Geometric Mean	Geometric Std. Dev.	Median
Northeast	§403 Risk Anal.	Prior to 1940	26	2700	265	15.8	176
	Interim NSLAH		40	395	86.8	6.95	91.7
	§403 Risk Anal.	1940 - 1959	17	98.5	32.6	5.55	50.7
	Interim NSLAH		23	62.7	19.6	4.49	18.9
	§403 Risk Anal.	1960 -1977 (1960-79 for §403)	10	499	38.9	20.8	217
	Interim NSLAH		21	14.7	8.39	2.55	7.37
	Interim NSLAH	After 1977	16	18.6	4.80	3.80	3.73
Midwest	§403 Risk Anal.	Prior to 1940	19	1660	435	5.79	542
	Interim NSLAH		35	355	67.3	5.61	60.1
	§403 Risk Anal.	1940 - 1959	21	98.2	17.7	11.6	17.4
	Interim NSLAH		35	104	19.9	5.51	15.7
	§403 Risk Anal.	1960 -1977 (1960-79 for §403)	29	223	20.9	11.6	48.3
	Interim NSLAH		37	28.4	10.3	3.81	9.54
	§403 Risk Anal.	After 1977 (1979 for §403)	4	62.5	27.5	6.78	83.0
	Interim NSLAH		30	21.4	7.01	3.54	6.20
South	§403 Risk Anal.	Prior to 1940	19	2450	64.0	23.1	24.4
	Interim NSLAH		25	606	105	5.94	115
	§403 Risk Anal.	1940 - 1959	33	657	38.9	9.93	26.2
	Interim NSLAH		43	165	31.8	7.16	27.3
	§403 Risk Anal.	1960 -1977 (1960-79 for §403)	64	149	24.0	12.6	32.0
	Interim NSLAH		74	59.4	13.9	5.32	12.6
	§403 Risk Anal.	After 1977 (1979 for §403)	18	112	9.09	8.60	7.58
	Interim NSLAH		72	19.0	4.63	3.93	3.62
West	§403 Risk Anal.	Prior to 1940	13	125	11.5	14.7	7.05
	Interim NSLAH		10	49.8	15.9	4.41	17.2
	§403 Risk Anal.	1940 - 1959	16	107	7.35	13.2	6.96
	Interim NSLAH		36	188	27.9	6.61	33.3
	§403 Risk Anal.	1960 -1977 (1960-79 for §403)	17	58.7	3.83	11.5	4.35
	Interim NSLAH		57	25.5	7.39	3.92	6.26
	§403 Risk Anal.	After 1977 (1979 for §403)	6	9.66	2.65	11.6	5.94
	Interim NSLAH		48	5.32	2.35	3.01	1.68

APPENDIX D2

SUMMARIES OF INTERIM YARD-WIDE AVERAGE SOIL-LEAD CONCENTRATION DATA FROM THE NATIONAL SURVEY OF LEAD AND ALLERGENS IN HOUSING (NSLAH), WHERE IMPUTED DATA ARE EXCLUDED

Summaries of Interim Yard-Wide Average Soil-Lead Concentration Data from the National Survey of Lead and Allergens in Housing (NSLAH), Where Imputed Data Are Excluded

This appendix presents descriptive statistics of yard-wide average soil-lead concentration from the §403 risk analysis and from the interim NSLAH dust-lead loading data where imputed data values calculated based on the methods presented in Appendix C are omitted. These summaries complement the summary tables and boxplots presented in Tables 3-18 through 3-21b and Figures 3-12 through 3-14 in the main body of this report, which included imputed household averages for housing units having no soil-lead concentration data from anywhere in the yard.

As in Appendix D1, the statistics on the interim NSLAH data are provided in this appendix under the following five different approaches to handling sample results that fall below the instrument's detection limit.

- No adjustment (i.e., using data as reported in the database)
- Replacing the value with zero
- Replacing the value with the detection limit (LOD) divided by two
- Replacing the value with the detection limit divided by the square root of two
- Replacing the value with the detection limit

(See Appendix D1 for details.) Results are presented under these different approaches to illustrate the impact that any one approach has on the characterized distribution.

The following tables appearing in this appendix are associated with the specified tables in Chapter 3 of the report:

- Table D2-1: national estimates complementing Table 3-18
- Table D2-2: estimates by housing age category, complementing Table 3-19
- Table D2-3: estimates by Census region, complementing Table 3-20
- Tables D2-4a and D2-4b: estimates by combinations of Census region and housing age category, complementing Tables 3-21a and 3-21b.

The following boxplots appearing in this appendix are associated with the specified boxplots in Chapter 3 of the report:

- Figure D2-1: national estimates complementing Figure 3-12
- Figure D2-2: estimates by housing age category, complementing Figure 3-13
- Figure D2-3: estimates by Census region, complementing Figure 3-14.

While Tables D2-1 and D2-2 and Figure D2-1 contain interim NSLAH data summaries under all five approaches to handling not-detected values, the remaining tables and figures in this appendix present interim NSLAH data summaries only for the two approaches (no adjustment; replace by one-half of the level of detection) most likely to be used in the supplemental risk analysis and considered in the interim NSLAH data summaries presented in Chapter 3.

Table D2-1. Descriptive Statistics of Yard-Wide Average Soil-Lead Concentrations for Households, As Reported in the §403 Risk Analysis Versus the Interim NSLAH Data (imputed data omitted for the NSLAH)

Study	How Not-Detected and Negative Data were Handled	Yard-Wide Average Soil-Lead Concentration (μg/g)[1]								
		# Surveyed Units with Positive Averages	Arith-metic Mean	Geo-metric Mean[2]	Geo-metric Std. Dev.[2]	Minimum	25th Percen-tile	Median	75th Percen-tile	Maximum
§403 Risk Analysis (HUD Natl. Survey)		284	235	61.9	4.46	4.63	21.3	49.2	142	7030
Interim NSLAH	No adjustment	647	198	50.5	5.13	0.00	16.1	40.6	145	9270
Interim NSLAH	Replaced by 0	608	197	58.2	4.72	0.00	14.3	39.2	145	9270
Interim NSLAH	Replaced by LOD/2	664	198	50.1	4.74	4.62	15.6	40.6	145	9270
Interim NSLAH	Replaced by LOD/√2	664	199	52.7	4.45	6.53	16.4	40.6	145	9270
Interim NSLAH	Replaced by LOD	664	199	55.8	4.17	9.23	17.0	40.6	145	9270

[1] All statistics are calculated by weighting each household by its sampling weight.
[2] Only household averages greater than zero are used to calculate this value (data for all units with soil-lead data are used to calculate the remaining statistics).
Note: The yard-wide average for a household is the average of the following two statistics: 1) the average of the mid-yard sample results, and 2) the average of results for the dripline and entryway samples.

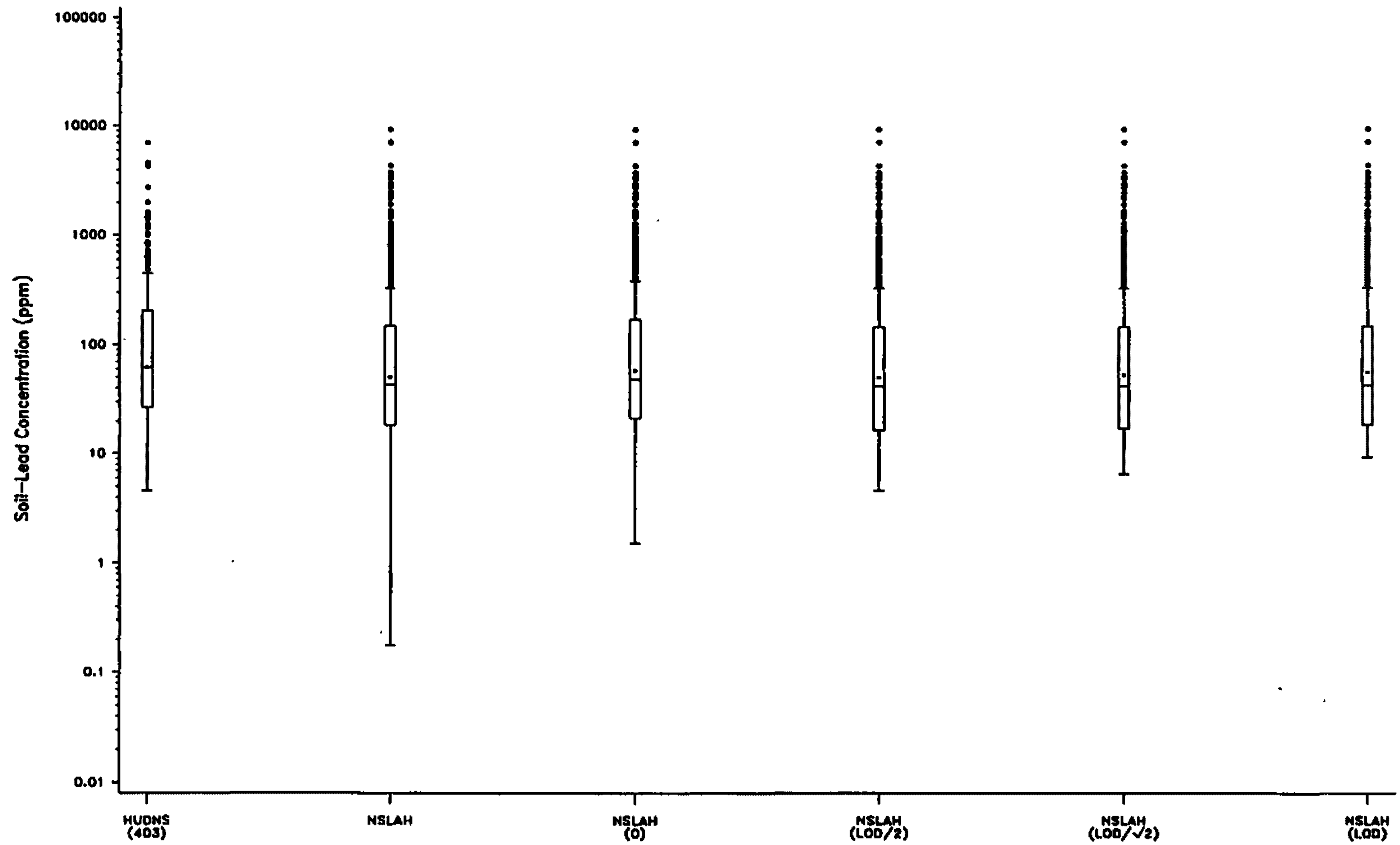

Figure D2-1. Boxplots of Yard-Wide Average Soil-Lead Concentrations (µg/g) As Observed in the §403 Risk Analysis (Using HUD National Survey Data) and in the NSLAH (under 5 approaches to handling not-detected values) (imputed data omitted for the NSLAH)

Table D2-2. Descriptive Statistics of Yard-Wide Average Soil-Lead Concentration for Households, Presented by Housing Age Category, As Reported in the §403 Risk Analysis Versus the Interim NSLAH Data (imputed data omitted for the NSLAH)

Study	How Not-Detected and Negative Data were Handled	Yard-Wide Average Soil-Lead Concentration (µg/g)[1]								
		# Units with Positive Averages	Arithmetic Mean	Geometric Mean[2]	Geometric Std. Dev.[2]	Minimum	25th Percentile	Median	75th Percentile	Maximum
Units Built Prior to 1940										
§403 Risk Analysis (HUD Natl. Survey)		77	761	463	3.09	17.4	259	569	1030	4620
Interim NSLAH	No adjustment	104	651	284	3.66	12.8	132	279	571	9270
	Replaced by 0	104	651	283	3.71	8.33	132	277	571	9270
	Replaced by LOD/2	104	651	284	3.67	10.8	132	279	571	9270
	Replaced by LOD/√2	104	651	284	3.66	11.9	132	280	571	9270
	Replaced by LOD	104	651	285	3.65	13.3	132	281	571	9270
Units Built from 1940 - 1959										
§403 Risk Analysis (HUD Natl. Survey)		87	287	92.6	3.15	5.40	44.3	77.3	162	7030
Interim NSLAH	No adjustment	138	264	107	3.49	1.65	43.1	91.9	223	4340
	Replaced by 0	137	264	109	3.36	0.00	43.1	91.9	223	4340
	Replaced by LOD/2	138	264	108	3.39	4.62	43.1	91.9	223	4340
	Replaced by LOD/√2	138	264	109	3.35	6.53	43.1	91.9	223	4340
	Replaced by LOD	138	264	109	3.31	9.23	43.1	91.9	223	4340
Units Built from 1960-1977 (1960 - 1979 for the §403 risk analysis)										
§403 Risk Analysis (HUD Natl. Survey)		120	55.0	32.8	2.56	4.63	19.7	29.7	61.6	996
Interim NSLAH	No adjustment	190	76.7	31.1	3.69	0.00	13.7	27.7	59.3	1120
	Replaced by 0	182	76.0	33.9	3.45	0.00	12.1	27.2	59.3	1120
	Replaced by LOD/2	193	77.2	32.6	3.27	4.83	14.7	28.3	59.3	1120
	Replaced by LOD/√2	193	77.7	34.2	3.08	6.83	15.3	28.4	59.3	1120
	Replaced by LOD	193	78.4	36.2	2.91	9.66	16.3	28.6	59.3	1120

Table D2-2. (cont.)

Study	How Not-Detected and Negative Data were Handled	Yard-Wide Average Soil-Lead Concentration (µg/g)[1]								
		# Units with Positive Averages	Arith-metic Mean	Geo-metric Mean[2]	Geo-metric Std. Dev.[2]	Minimum	25th Percen-tile	Median	75th Percen-tile	Maximum
Units Built After 1977 (after 1979 for the §403 risk analysis)										
§403 Risk Analysis (HUD Natl. Survey)		28	31.3	22.4	2.31	5.35	13.6	21.2	45.0	97.4
Interim NSLAH	No adjustment	160	27.6	15.2	3.29	0.00	5.67	14.3	32.9	474
Interim NSLAH	Replaced by 0	131	26.1	18.6	2.98	0.00	1.89	12.0	32.9	472
Interim NSLAH	Replaced by LOD/2	172	28.3	15.7	2.71	4.65	6.24	14.5	32.9	475
Interim NSLAH	Replaced by LOD/√2	172	29.3	17.7	2.43	6.57	7.87	15.2	32.9	476
Interim NSLAH	Replaced by LOD	172	30.6	20.2	2.18	9.30	10.3	16.0	32.9	477
NSLAH Units with Unspecified Year-Built Indicator										
Interim NSLAH	No adjustment	55	169	66.6	4.26	0.00	19.4	49.6	158	2290
Interim NSLAH	Replaced by 0	54	168	70.3	3.99	0.00	17.9	49.6	158	2290
Interim NSLAH	Replaced by LOD/2	57	169	62.7	4.21	4.74	19.4	49.6	158	2290
Interim NSLAH	Replaced by LOD/√2	57	169	64.8	4.02	6.70	19.4	49.6	158	2290
Interim NSLAH	Replaced by LOD	57	170	67.2	3.84	9.47	19.4	49.6	158	2290

[1] All statistics are calculated by weighting each household by its sampling weight.
[2] Only household averages greater than zero are used to calculate this value (data for all units with soil-lead data are used to calculate the remaining statistics).
Note: The yard-wide average for a household is the average of the following two statistics: 1) the average of the mid-yard sample results, and 2) the average of results for the dripline and entryway samples.

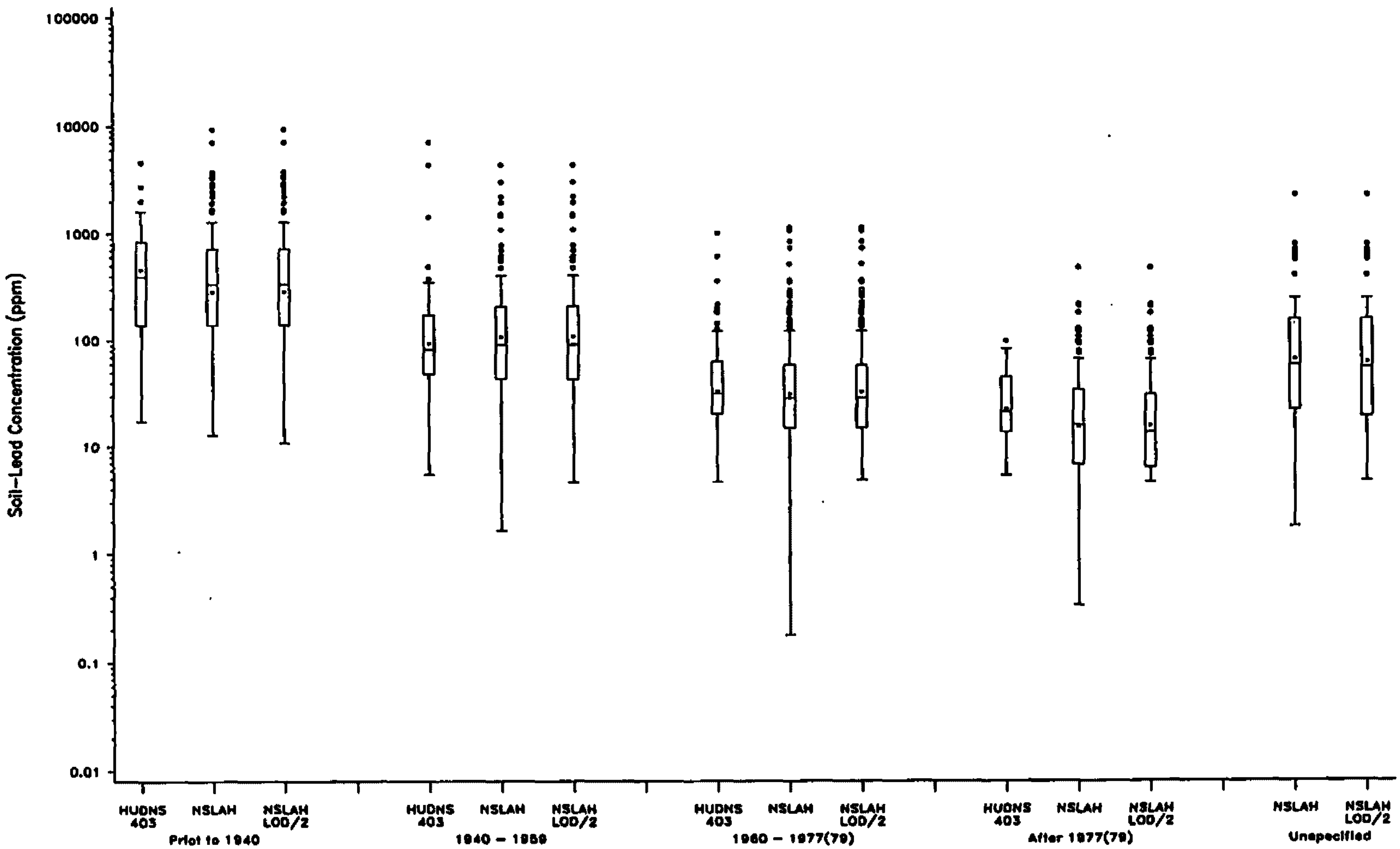

Figure D2-2. Boxplots of Yard-Wide Average Soil-Lead Concentration (µg/g), by Housing Age Category, As Observed in the §403 Risk Analysis (Using HUD National Survey Data) and in the NSLAH (under 2 approaches to handling not-detected values) (imputed data omitted for the NSLAH)

Table D2-3. Descriptive Statistics of Yard-Wide Average Soil-Lead Concentration for Households, Presented by Census Region, As Reported in the §403 Risk Analysis Versus the Interim NSLAH Data (imputed data omitted for the NSLAH)

Study	How Not-Detected and Negative Data were Handled	Yard-Wide Average Soil-Lead Concentration (µg/g)[1]								
		# Surveyed Units with Positive Averages	Arith-metic Mean	Geo-metric Mean[2]	Geo-metric Std. Dev.[2]	Minimum	25th Percen-tile	Median	75th Percen-tile	Maximum
Northeast										
§403 Risk Analysis (HUD Natl. Survey)		53	437	206	3.58	14.8	60.1	279	569	4320
Interim NSLAH	No adjustment	95	435	160	4.29	3.92	56.1	176	396	3460
Interim NSLAH	Replaced by LOD/2	95	435	161	4.20	6.24	56.1	176	396	3460
Midwest										
§403 Risk Analysis (HUD Natl. Survey)		73	404	81.4	6.33	4.63	19.7	51.6	264	2750
Interim NSLAH	No adjustment	143	221	63.6	5.05	0.00	20.8	59.5	206	7070
Interim NSLAH	Replaced by LOD/2	144	221	63.8	4.77	4.90	20.6	59.5	206	7070
South										
§403 Risk Analysis (HUD Natl. Survey)		134	125	44.5	2.94	5.22	22.6	40.8	79.3	7030
Interim NSLAH	No adjustment	250	161	36.4	4.60	0.00	11.5	27.2	78.6	9270
Interim NSLAH	Replaced by LOD/2	257	161	35.5	4.36	4.65	12.6	27.2	78.6	9270
West										
§403 Risk Analysis (HUD Natl. Survey)		52	112	34.4	3.92	4.79	14.2	27.2	61.6	2020
Interim NSLAH	No adjustment	159	61.7	28.0	4.35	0.00	10.4	29.4	70.0	776
Interim NSLAH	Replaced by LOD/2	168	62.5	29.3	3.48	4.62	11.2	29.4	70.0	776

[1] All statistics are calculated by weighting each household by its sampling weight.
[2] Only household averages greater than zero are used to calculate this value (data for all units with soil-lead data are used to calculate the remaining statistics).
Note: The yard-wide average for a household is the average of the following two statistics: 1) the average of the mid-yard sample results, and 2) the average of results for the dripline and entryway samples.

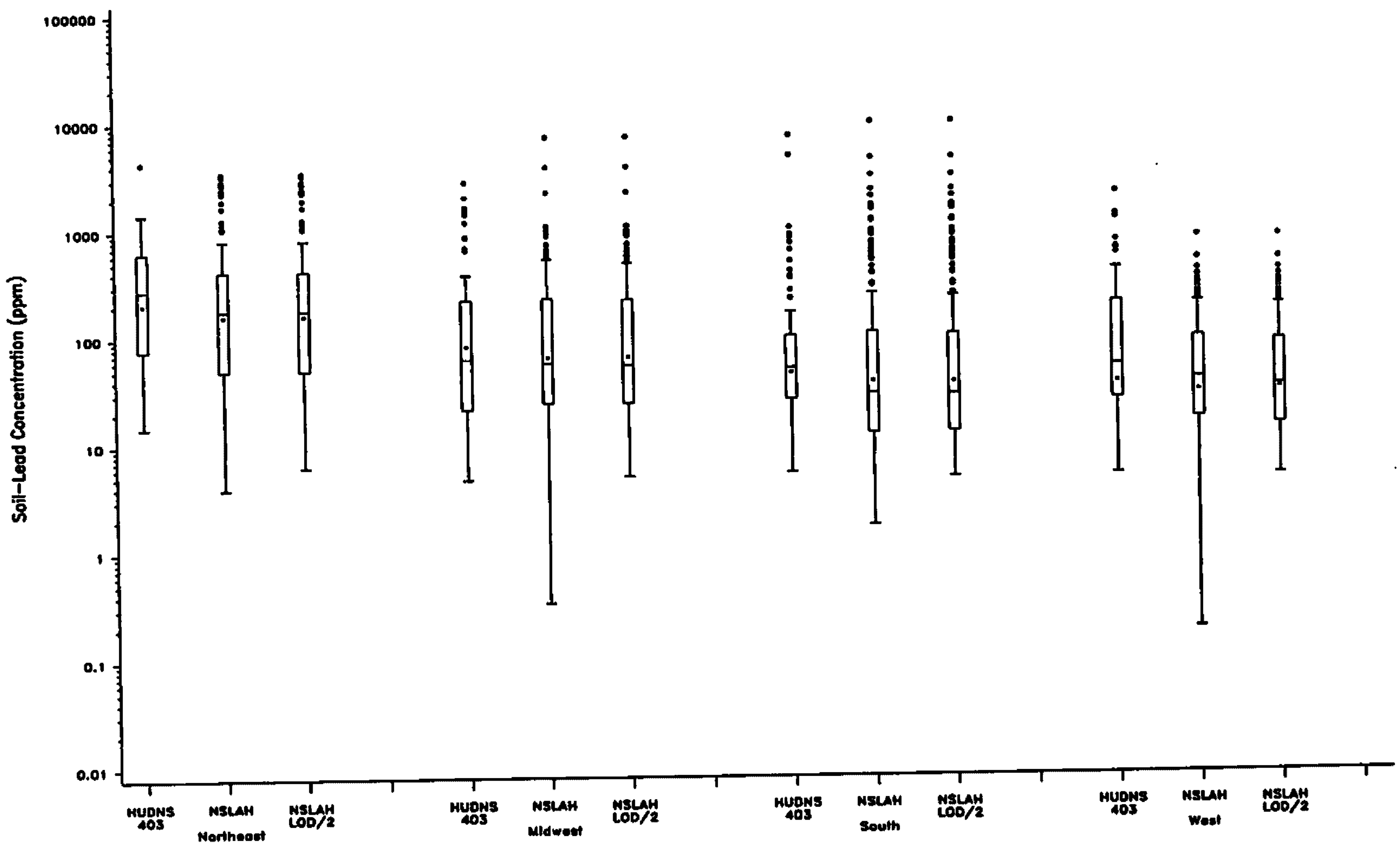

Figure D2-3. Boxplots of Yard-Wide Average Soil-Lead Concentration (μg/g), by Census Region, As Observed in the §403 Risk Analysis (Using HUD National Survey Data) and in the NSLAH (under 2 approaches to handling not-detected values) (imputed data omitted for the NSLAH)

Table D2-4a. Descriptive Statistics of Yard-Wide Average Soil-Lead Concentrations for Households, Presented by Housing Age and Census Region, As Reported in the §403 Risk Analysis Versus the Interim NSLAH Data Where No Adjustments Were Made to Not-Detected Results (imputed data omitted for the NSLAH)

Census Region	Study	Housing Age Category	Yard-Wide Average Soil-Lead Concentration[1] (µg/g)				
			# Surveyed Units	Arithmetic Mean	Geometric Mean[3]	Geometric Std. Dev.[3]	Median
Northeast	§403 Risk Anal.	Prior to 1940	26	542	491	1.57	444
	Interim NSLAH		35	903	471	3.49	461
	§403 Risk Anal.	1940 - 1959	17	573	136	4.40	60.1
	Interim NSLAH		20	292	193	2.31	194
	§403 Risk Anal.	1960 -1977 (1960-79 for §403)	10	79.1	60.7	2.15	69.7
	Interim NSLAH		19	138	66.3	3.07	50.9
	Interim NSLAH	After 1977	15	62.6	42.9	2.76	43.1
Midwest	§403 Risk Anal.	Prior to 1940	19	1310	941	2.68	1390
	Interim NSLAH		35	505	225	3.39	273
	§403 Risk Anal.	1940 - 1959	21	127	92.6	2.41	123
	Interim NSLAH		35	233	102	3.18	75.7
	§403 Risk Anal.	1960 -1977 (1960-79 for §403)	29	42.7	27.1	2.32	23.4
	Interim NSLAH		35	95.5	37.8	3.42	32.0
	§403 Risk Anal.	After 1977 (1979 for §403)	4	13.0	11.5	1.66	12.4
	Interim NSLAH		28	34.3	12.8	3.97	9.36
South	§403 Risk Anal.	Prior to 1940	19	417	174	3.68	159
	Interim NSLAH		24	694	270	3.84	186
	§403 Risk Anal.	1940 - 1959	33	327	83.1	3.27	81.0
	Interim NSLAH		47	366	95.2	4.43	64.5
	§403 Risk Anal.	1960 -1977 (1960-79 for §403)	64	54.6	36.5	2.30	34.7
	Interim NSLAH		78	68.9	26.8	3.61	26.1
	§403 Risk Anal.	After 1977 (1979 for §403)	18	38.5	29.7	2.11	25.0
	Interim NSLAH		79	22.2	15.6	2.47	15.0
West	§403 Risk Anal.	Prior to 1940	13	594	295	3.76	394
	Interim NSLAH		10	153	119	2.27	158
	§403 Risk Anal.	1940 - 1959	16	96.8	72.1	2.19	60.4
	Interim NSLAH		36	136	81.6	3.08	89.5
	§403 Risk Anal.	1960 -1977 (1960-79 for §403)	17	56.2	23.8	3.02	20.0
	Interim NSLAH		58	44.6	23.4	3.77	26.3
	§403 Risk Anal.	After 1977 (1979 for §403)	6	21.7	15.0	2.34	13.6
	Interim NSLAH		38	16.1	9.01	3.73	5.88

[1] All statistics are calculated by weighting each household by its sampling weight.

[3] Only household averages greater than zero are used to calculate this value (data for all units with soil-lead data are used to calculate the remaining statistics).

Note: The yard-wide average for a household is the average of the following two statistics: 1) the average of the mid-yard sample results, and 2) the average of results for the dripline and entryway samples.

Table D2-4b. Descriptive Statistics of Yard-Wide Average Soil-Lead Concentrations for Households, Presented by Housing Age and Census Region, As Reported in the §403 Risk Analysis Versus the Interim NSLAH Data Where Not-Detected Results Were Replaced by LOD/2 (imputed data omitted for the NSLAH)

Census Region	Study	Housing Age Category	Yard-Wide Average Soil-Lead Concentration[1] (µg/g)				
			# Surveyed Units	Arithmetic Mean	Geometric Mean	Geometric Std. Dev.	Median
Northeast	§403 Risk Anal.	Prior to 1940	26	542	491	1.57	444
	Interim NSLAH		35	903	469	3.53	461
	§403 Risk Anal.	1940 - 1959	17	573	136	4.40	60.1
	Interim NSLAH		20	292	193	2.31	194
	§403 Risk Anal.	1960 -1977 (1960-79 for §403)	10	79.1	60.7	2.15	69.7
	Interim NSLAH		19	138	66.1	3.08	50.9
	Interim NSLAH	After 1977	15	62.8	45.1	2.45	43.1
Midwest	§403 Risk Anal.	Prior to 1940	19	1310	941	2.68	1390
	Interim NSLAH		35	505	225	3.38	273
	§403 Risk Anal.	1940 - 1959	21	127	92.6	2.41	123
	Interim NSLAH		35	233	103	3.15	75.7
	§403 Risk Anal.	1960 -1977 (1960-79 for §403)	29	42.7	27.1	2.32	23.4
	Interim NSLAH		35	95.8	38.5	3.34	32.0
	§403 Risk Anal.	After 1977 (1979 for §403)	4	13.0	11.5	1.66	12.4
	Interim NSLAH		29	34.9	13.8	3.09	9.67
South	§403 Risk Anal.	Prior to 1940	19	417	174	3.68	159
	Interim NSLAH		24	694	270	3.84	186
	§403 Risk Anal.	1940 - 1959	33	327	83.1	3.27	81.0
	Interim NSLAH		47	366	96.3	4.37	64.5
	§403 Risk Anal.	1960 -1977 (1960-79 for §403)	64	54.6	36.5	2.30	34.7
	Interim NSLAH		80	69.5	27.7	3.25	26.1
	§403 Risk Anal.	After 1977 (1979 for §403)	18	38.5	29.7	2.11	25.0
	Interim NSLAH		82	22.7	15.3	2.30	14.7
West	§403 Risk Anal.	Prior to 1940	13	594	295	3.76	394
	Interim NSLAH		10	154	120	2.25	158
	§403 Risk Anal.	1940 - 1959	16	96.8	72.1	2.19	60.4
	Interim NSLAH		36	136	84.5	2.76	89.5
	§403 Risk Anal.	1960 -1977 (1960-79 for §403)	17	56.2	23.8	3.02	20.0
	Interim NSLAH		59	45.2	26.4	2.85	26.3
	§403 Risk Anal.	After 1977 (1979 for §403)	6	21.7	15.0	2.34	13.6
	Interim NSLAH		46	17.9	10.8	2.44	7.68

[1] All statistics are calculated by weighting each household by its sampling weight.

Note: The yard-wide average for a household is the average of the following two statistics: 1) the average of the mid-yard sample results, and 2) the average of results for the dripline and entryway samples.

APPENDIX E

METHOD TO ESTIMATING TOTAL SOIL-LEAD CONCENTRATION FROM ANALYTICAL RESULTS FOR FINE AND COARSE SOIL FRACTIONS

Method to Estimating Total Soil-Lead Concentration from Analytical Results for the Fine and Coarse Soil Fractions

In an effort to reflect bioavailable lead in soil, the Rochester Lead-in-Dust study partitioned their collected soil samples into fine- and coarse-sieved fractions. The soil-lead concentration of the complete sample (i.e., total soil) was not measured. The absence of such a measure limits the ability to compare the soil results from the Rochester study with those of other studies. The recent Milwaukee study, however, also fractioned their soil samples but made provisions to simultaneously measure total soil-lead. This appendix describes an effort to use the results of the Milwaukee study to estimate the soil-lead concentration of total soil for samples collected in the Rochester study.

The Milwaukee study data available for this analysis represented 66 paired samples collected at the child's play area and the residence's drip line. The same sieve-fraction used in the Rochester was employed in Milwaukee. For each collected sample, the lead concentration of fine-sieved, coarse-sieved and total soil was measured. The mass of each soil fraction was not reported.

Figures E-1 and E-2 compare the Milwaukee and Rochester study data. In particular, these figures plot the coarse versus the fine soil-lead concentrations for the play area and drip line measurements, respectively. Distinct plotting symbols delineate samples from the two studies. These plots show that the data range and scatter about the trend line are considerably greater in the Rochester study than in the Milwaukee study.

A likelihood ratio test was used to assess whether linear models for the two studies were statistically different. Results for play area samples in the two studies (Figure E-1) do evidence statistically ($p<.01$) distinct linear relationships between fine- and coarse-sieved soil-lead concentrations. Results for drip line samples in the two studies (Figure E-2) were not statistically distinct at the 0.05 level. These analyses suggest there are some differences in the fine- versus coarse-sieved soil-lead concentration relationships measured in these studies. These differences should be acknowledged when considering the merits of the Rochester total soil estimation procedure outlined below.

To estimate the soil-lead concentration of total soil, it is useful to consider how total soil-lead concentration may be calculated from fine- and coarse-sieve soil-lead concentrations and masses. Specifically, let x_f/y_f and x_c/y_c represent the micrograms of lead (x) per gram of soil (y) for fine- and coarse-sieved fractions, respectively, of a soil sample. The sample's total soil-lead concentration, then, can be written as follows:

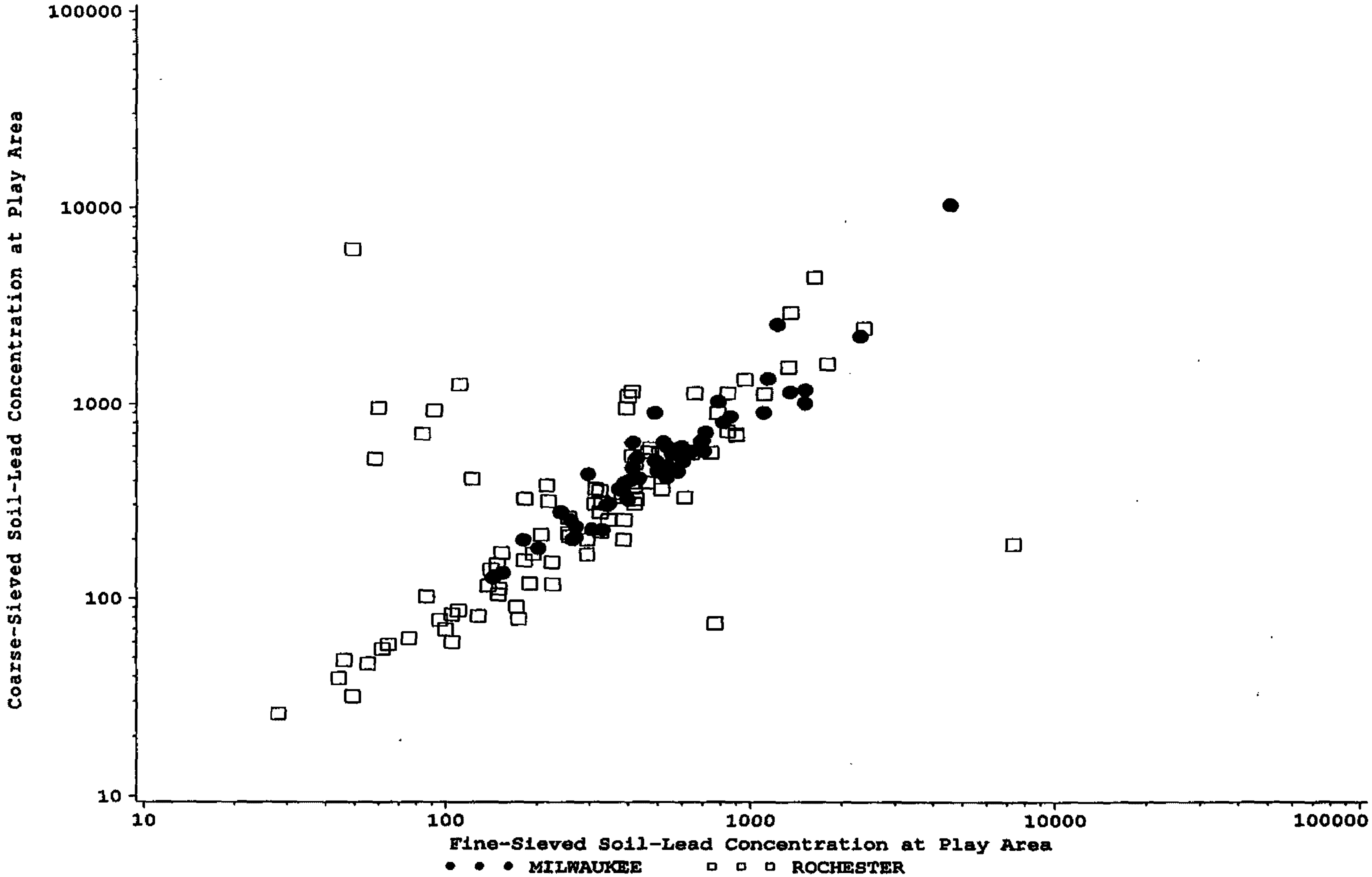

Figure E-1. Coarse- versus Fine-Sieved Soil Lead Concentration Measured at Child's Play Area during Rochester and Milwaukee Studies

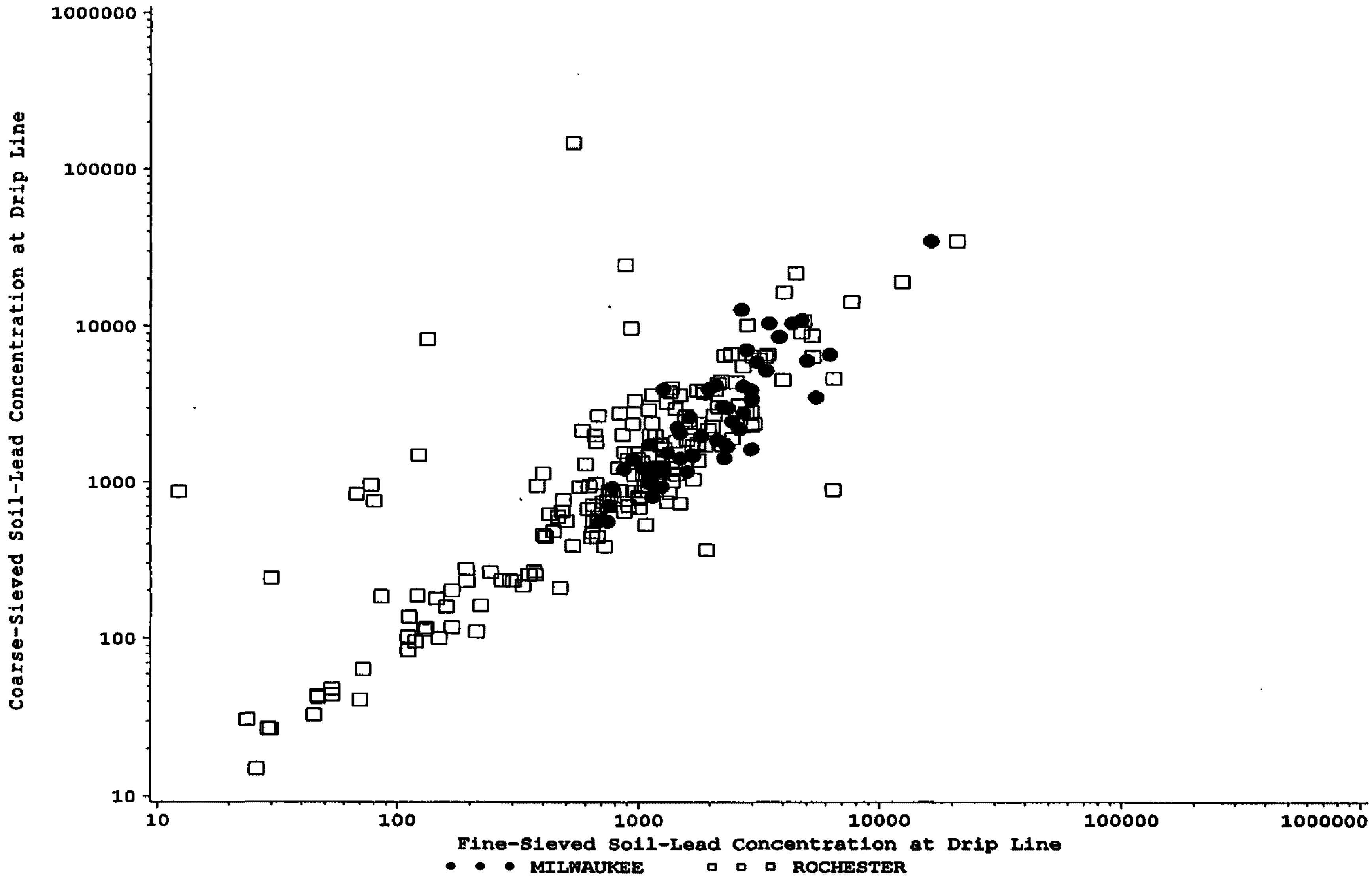

Figure E-2. Coarse- versus Fine-Sieved Soil Lead Concentration Measured at the Drip Line during Rochester and Milwaukee Studies

$$\frac{x_f + x_c}{y_f + y_c} = \frac{y_f}{y_f + y_c} \cdot \frac{x_f}{y_f} + \frac{y_c}{y_f + y_c} \cdot \frac{x_c}{y_c}$$

$$= \frac{y_f}{y_f + y_c} \cdot \frac{x_f}{y_f} + \left(1 - \frac{y_f}{y_f + y_c}\right) \cdot \frac{x_c}{y_c}$$

$$= \beta(y_f, y_c) \cdot \frac{x_f}{y_f} + \left(1 - \beta(y_f, y_c)\right) \cdot \frac{x_c}{y_c} \quad \text{where } \beta(y_f, y_c) = \frac{y_f}{y_f + y_c}.$$

Thus, a sample's total soil-lead concentration can be written as a function of the sample's fine-sieved soil mass fraction and the sample's fine- and coarse-sieved soil-lead concentrations. Since the sieved soil mass fractions were not reported in the Milwaukee study, some assumptions regarding these fractions were required. For the sake of simplicity, the fine-sieved soil mass fraction was assumed constant. The total soil-lead concentration, then, is a weighted combination of the fine- and coarse-sieved soil-lead concentrations,

$$\frac{x_f + x_c}{y_f + y_c} \cong \beta \cdot \frac{x_f}{y_f} + (1 - \beta) \cdot \frac{x_c}{y_c} \quad .$$

Such a simple model is critical since the fine- and coarse-sieved soil-lead concentrations were the only soil results reported in the Milwaukee study (i.e., no mass fraction data are available).

The model equation specified above was fit to both the play area and drip line data in the Milwaukee study using the NLIN procedure in the SAS® System. This module was used because it permitted the necessary link between the coefficients on fine- and coarse-sieved soil-lead concentration. The estimated value for β was approximately 0.25 when fitting the aforementioned relationship to the play area samples alone, the drip line samples alone, and to both sets of samples together. That is, the Milwaukee data suggested the following:

Total soil-lead concentration = 0.25·(Fine) + 0.75·(Coarse).

Figure E-3 presents the results of fitting the above model to the Milwaukee data. The plot is of the predicted total soil-lead concentration versus the observed total soil-lead concentrations. Distinct plotting symbols represent the different sampling locations (drip line or play area). As expected, the fit is more than reasonable for both locations.

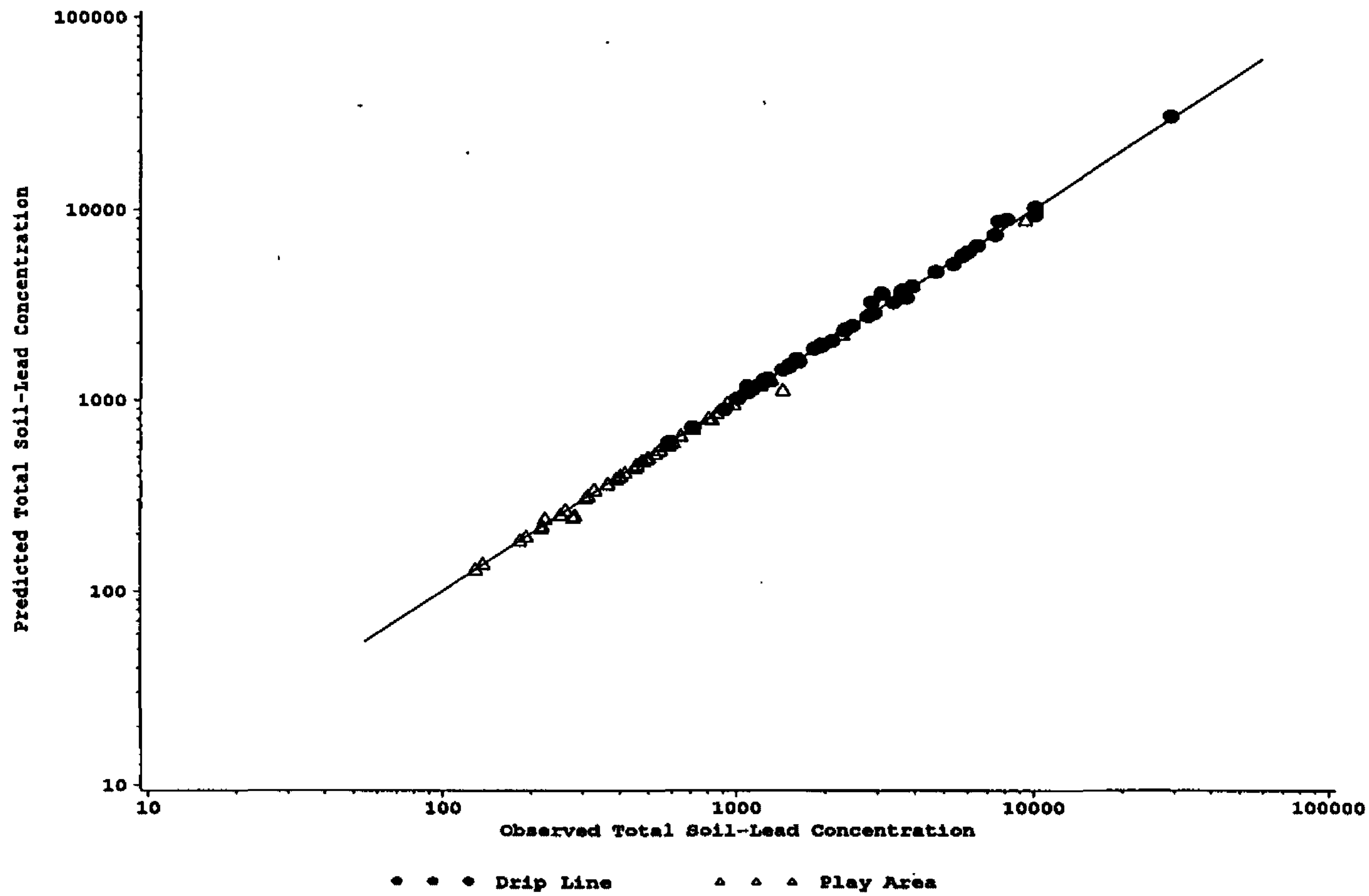

Figure E-3. Predicted versus Observed Total Soil-Lead Concentration by Sampling Location (Milwaukee Study)

APPENDIX F

COMPARISON AND CONTRAST OF RISK ESTIMATES FROM THE HUD MODEL AND THE ROCHESTER MULTIMEDIA MODEL DEVELOPED IN THE §403 RISK ANALYSIS

Comparison and Contrast of Risk Estimates from the HUD Model and the Multimedia Models Developed in the §403 Risk Analysis

To determine how blood-lead concentration as predicted by the HUD model differs from that predicted by the Rochester multimedia model, the HUD model results presented in Tables 4 and 5 of Lanphear et al., 1998, were compared to results under the Rochester multimedia model given the same sets of input values considered in these two tables. HUD model results presented in this appendix were taken from these two tables. However, when interpreting how these results compare across the two models in this exercise, one should recall that the HUD model assumes that input environmental-lead levels are "true" levels. This is the result of measurement error adjustments made to this model, which were not made to the Rochester multimedia model. Thus, estimates under the Rochester multimedia model assume that environmental-lead levels input to the model are measurements that result from a risk assessment.

Tables 4 and 5 of Lanphear et al., 1998, reflected HUD model fits for all combinations of the following:

- Floor (wipe) dust-lead loadings of 1, 5, 10, 15, 20, 25, 40, 50, 55, 70, and 100 $\mu g/ft^2$
- Soil-lead concentrations of 10, 72, 100, 400, 500, 1000, 1500, 2000, and 4000 ppm.

These same input values were also considered in this exercise. This list includes the proposed §403 hazard standard for soil (2000 ppm) and national median levels (according to Lanphear et al., 1998) for floor dust-lead loading (5 $\mu g/ft^2$) and soil-lead concentration (72 ppm). In addition, for the Rochester multimedia model, a floor dust-lead loading of 50 $\mu g/ft^2$ (i.e., the proposed §403 hazard standard for floor-dust) and a soil-lead concentration of 400 ppm (i.e., the proposed §403 soil-lead level of concern) were added to the list of input values.

As the Rochester multimedia model requires window sill (wipe) dust-lead loading as input, a value of 27.5 $\mu g/ft^2$ was used. This value represents the national median dust-lead loading for window sills, as estimated within the §403 risk analysis using HUD National Survey data, with sampling weights updated to reflect the 1997 housing stock (the §403 risk analysis report) and Blue Nozzle vacuum dust-lead loadings converted to wipe-equivalents using conversion equations found in USEPA, 1997.

According to Lanphear et al., 1998, all HUD model fits assumed that maximum interior paint-lead concentration was set at 1.6 mg/cm^2 and water-lead concentration at 1 ppb; these values represented national median levels. The age of child was specified as 16 months (the mean age across all of the pooled data on which the model was developed), and values of categorical variables were taken to be the average across the population represented by the pooled data. The HUD model fits assumed no exposure to damaged paint, and exterior-lead exposures were estimated from dripline soil samples.

F.1 COMPARING THE ESTIMATED GEOMETRIC MEAN BLOOD-LEAD CONCENTRATIONS

Tables F-1 and F-2 present geometric mean blood-lead concentrations (µg/dL) under each combination of the floor dust-lead loading and soil-lead concentration values mentioned above, as predicted by the HUD model and the Rochester Multimedia model, respectively.

Table F-1. Geometric Mean Blood-Lead Concentrations (µg/dL), as Predicted by the HUD Model for Specified Values of Environmental-Lead Levels[1]

Interior Floor Dust-Lead Loading (µg/ft²)[2]	Soil-Lead Concentration at the Foundation Perimeter (ppm)							
	10	72[3]	100	500	1000	1500	2000	4000
1	2.3	2.8	2.9	3.5	3.8	4.0	4.1	4.4
5[3]	3.2	4.0	4.1	4.9	5.3	5.5	5.7	6.1
10	3.7	4.6	4.7	5.6	6.1	6.3	6.5	7.1
15	4.0	5.0	5.1	6.1	6.6	6.9	7.4	7.7
20	4.2	5.3	5.4	6.5	7.0	7.3	7.6	8.1
25	4.4	5.5	5.7	6.8	7.3	7.7	7.9	8.5
40	4.9	6.1	6.3	7.5	8.1	8.4	8.7	9.4
55	5.2	6.5	6.7	8.0	8.6	9.0	9.3	10.0
70	5.5	6.8	7.0	8.4	9.1	9.5	9.8	10.5
100	5.9	7.3	7.6	9.0	9.7	10.2	10.5	11.3

[1] Taken from Table 4 of Lanphear et al., 1998. Table entries represent blood-lead concentrations for a 16-month old child (i.e., the mean age in HUD's pooled analysis). Water-lead concentration is assumed to be 1.0 ppb, an estimate of the national median as determined in Lanphear et al., 1998, from the pooled data and other sources. Maximum XRF paint-lead measurement is assumed to be 1.6 mg/cm², which is the median level based on data from the HUD National Survey. No exposure to damaged paint was assumed. The effects for other categorical model predictors (i.e., study, race, SES, mouthing behavior) were set to the arithmetic mean effect across the population represented by the study data.
[2] Assumes wipe dust collection techniques.
[3] Estimated median level based on data from the HUD National Survey, as determined in Lanphear et al., 1998. The median wipe dust-lead loading was determined by converting Blue Nozzle vacuum loadings from the HUD National Survey to wipe-equivalent loadings using a conversion equation published in Farfel et al., 1994.

Table F-2. Geometric Mean Blood-Lead Concentrations (µg/dL), as Predicted by the Rochester Multimedia Model for Specified Values of Environmental-Lead Levels[1]

Interior Floor Dust-Lead Loading (µg/ft²)[2]	Soil-Lead Concentration at the Drip Line (ppm)								
	10	72[3]	100	400	500	1000	1500	2000	4000
1	2.74	3.43	3.56	4.18	4.28	4.63	4.85	5.02	5.43
5[3]	3.05	3.82	3.96	4.64	4.76	5.15	5.40	5.58	6.04
10	3.19	4.00	4.15	4.86	4.99	5.40	5.65	5.84	6.32
15	3.28	4.11	4.26	4.99	5.12	5.54	5.80	6.00	6.49
20	3.34	4.18	4.34	5.09	5.22	5.65	5.92	6.11	6.61
25	3.39	4.25	4.41	5.16	5.30	5.73	6.00	6.20	6.71
40	3.50	4.38	4.55	5.33	5.46	5.91	6.19	6.40	6.92
50	3.55	4.45	4.61	5.40	5.54	6.00	6.28	6.49	7.03
55	3.57	4.47	4.64	5.44	5.58	6.04	6.32	6.53	7.07
70	3.63	4.55	4.72	5.53	5.67	6.13	6.43	6.64	7.19
100	3.72	4.65	4.83	5.66	5.80	6.28	6.58	6.80	7.36

[1] Window sill (wipe) dust-lead loading is assumed to be 27.5 µg/ft², the median area-weighted household average determined from HUD National Survey data (after converting Blue Nozzle dust-lead loadings to wipe-equivalent loadings and after updating the sample weights to reflect the 1997 housing stock, using methods developed for the §403 risk analysis). The reported geometric means in this table equal (0.91*A + 0.09*B), where A is the predicted geometric mean assuming PbP=0 (i.e., no deteriorated lead-based paint or paint pica tendencies in the child -- see Section 3.2), and B is the predicted geometric mean assuming PbP=1.5.
[2] Assumes wipe dust collection techniques.
[3] Estimated median level based on data from the HUD National Survey, as determined in Lanphear et al., 1998. The median wipe dust-lead loading was determined by converting Blue Nozzle vacuum loadings from the HUD National Survey to wipe-equivalent loadings using a conversion equation published in Farfel et al., 1994.

At median environmental-lead levels, the HUD model and Rochester Multimedia model estimates are very similar. The HUD model estimate of 4.0 µg/dL is only 4.7% above the Rochester Multimedia model estimate of 3.82 µg/dL. At the proposed §403 standards for floor-dust and soil (50 µg/ft² and 2000 ppm, respectively), the HUD model predicts a geometric mean blood-lead concentration of approximately 9.1 µg/dL, which is 40% above the Rochester Multimedia model estimate (6.49 µg/dL).

To more easily observe how model estimates change as dust-lead and soil-lead levels vary, Figures F-1a and F-1b portray the information in Tables F-1 and F-2 graphically. For each model, the two figures demonstrate how predicted geometric mean blood-lead concentration

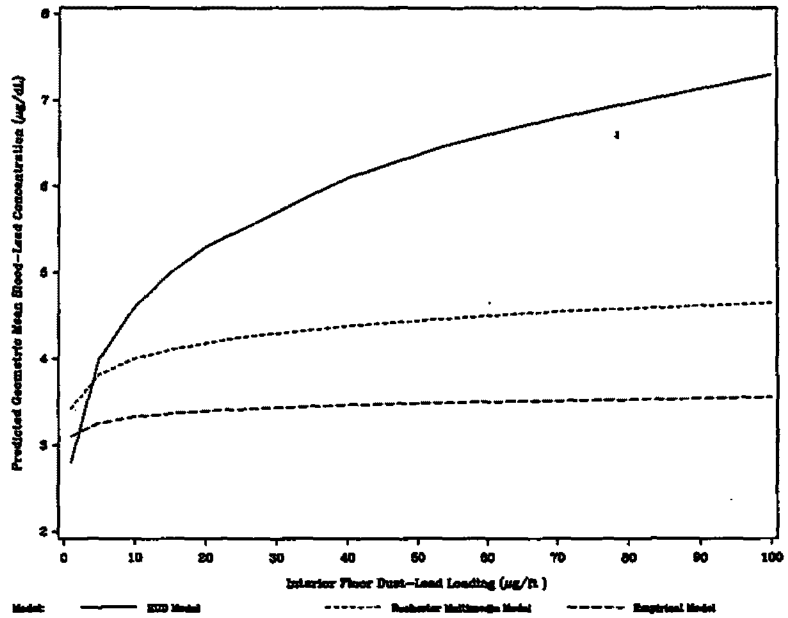

Figure F-1a. Predicted Geometric Mean Blood-Lead Concentration vs. Floor Dust-Lead Loading ($\mu g/ft^2$), Assuming Soil-Lead Concentration = 72 ppm

(see footnotes to Tables F-1 and F-2)

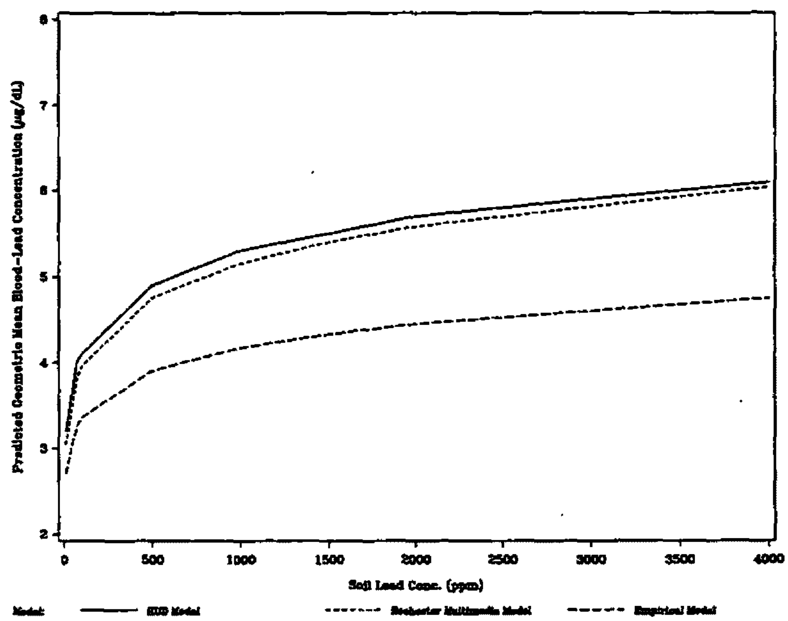

Figure F-1b. Predicted Geometric Mean Blood-Lead Concentration vs. Soil-Lead Concentration (ppm), Assuming Floor Dust-Lead Loading = 5 $\mu g/ft^2$

(see footnotes to Tables F-1 and F-2)

increases as either floor dust-lead loading (Figure F-1a) or soil-lead concentration (Figure F-1b) increases. While results for the empirical model (Section 4.2.5 of the §403 risk analysis report) are included in these figures, they should not be considered in the interpretation of results across models. In both figures, environmental-lead levels in media other than that specified on the horizontal axis are set at estimated national median levels, as indicated in the footnotes of Tables F-1 and F-2.

Figure F-1a shows that HUD model estimates become considerably higher than those for the Rochester multimedia model when floor dust-lead loadings increase. As floor dust-lead loading increases from 1 to 100 $\mu g/ft^2$ and other environmental media are at their estimated national median levels (e.g., soil-lead concentration = 72 ppm), predicted blood-lead concentrations under the HUD model increase three-fold. In contrast, estimates under the Rochester multimedia model increase by 35%. In the settings represented within Figure 3-1a, the HUD model estimates are similar to or lower than those for the Rochester multimedia model only at very low floor dust-lead loadings (i.e., less than 10 $\mu g/ft^2$). However, inferences at such low loadings must be done with extreme caution.

Figure 3-1b shows a different relationship than that seen in Figure 3-1a. In this plot, soil-lead concentration increases from 10 to 4000 ppm, but floor dust-lead loading is fixed at 5 $\mu g/ft^2$. In this setting, estimates between the HUD model and the Rochester multimedia model are nearly the same across the range of soil-lead concentrations. However, inferences at such a low floor dust-lead loading must be made with caution in these models.

The extent of difference in the predicted geometric mean blood-lead concentration between the HUD and Rochester multimedia model estimates gets larger as the assumed dust-lead loading increases and as soil-lead concentration decreases. Among the different combinations of dust-lead and soil-lead levels utilized in the model fits, the HUD model estimate differs greatly at the largest dust-lead loading (100 $\mu g/ft^2$) and the lowest soil-lead concentration (10 ppm), where this estimate (5.9 µg/dL) is a 59% increase over the Rochester multimedia model estimate (3.72 µg/dL).

F.2 Comparisons of the Estimated Percentage of Children With Blood-Lead Concentrations At or Above 10 µg/dL

When an estimated geometric mean (GM) from the previous sub-section is combined with an assumed geometric standard deviation (GSD) on the distribution of blood-lead concentration, and if this distribution is assumed to be lognormal, then the probability of observing blood-lead concentrations at or above 10 µg/dL (the lowest blood-lead concentration considered elevated by the Centers for Disease Control and Prevention) is calculated as

$$P[PbB \geq 10] = 1 - \Phi\left(\frac{\ln(10) - \ln(GM)}{\ln(GSD)}\right)$$

where $\Phi(z)$ is the probability of observing a value less than z under the standard normal distribution. This sub-section presents estimates of this probability (expressed in percentage terms) under the estimated geometric means in Tables F-1 and F-2 and under three different assumptions on the geometric standard deviation (GSD):

- GSD=1.6, used to represent within-house variability in the §403 risk analysis
- GSD=1.72, assumed in Lanphear et al., 1998
- GSD=1.75, calculated from data in the Rochester Lead-in-Dust study

Tables F-3 and F-4 present the estimated percentages under the HUD model and the Rochester Multimedia model, respectively.

When GSD=1.72 and at estimated median environmental-lead levels, Tables F-3 and F-4 indicate that the estimated percentages are similar between the HUD model (4.56%) and the Rochester multimedia model (3.79%). While the similarity was expected given the similar geometric means observed in the previous sub-section, the HUD model estimate is approximately 20% higher than the Rochester multimedia model estimate, which is a higher rate of increase than the 4% increase observed in the estimated geometric mean. Furthermore, these estimates can change considerably with the GSD. For example, under GSD=1.6, the estimates are 45-55% lower (2.56% under the HUD model, 2.03% under the Rochester multimedia model) than their respective values under GSD=1.72.

Figures F-2a and F-2b portray how the estimated percentages of blood-lead concentrations at or above 10 µg/dL increase as dust-lead and soil-lead levels, respectively, are increased. These estimates coincide with the geometric mean estimates plotted in Figures F-1a and F-1b and are calculated under the same underlying assumptions (i.e., national median levels are assumed for media not specified on the horizontal axis). Each figure contains three plots, one for each assumed GSD value.

Figure 3-2a shows that at an assumed soil-lead concentration of 72 ppm, the HUD model estimates become markedly increased as floor dust-lead loading increases to 100 µg/ft^2. At 100 µg/ft^2, the HUD model estimates from 25% to 29% of children have blood-lead concentrations at or above 10 µg/dL (under GSD values from 1.6 to 1.75), while these estimates range from 5% to 9% under the Rochester multimedia model.

In contrast, Figure 3-2b shows that at an assumed floor dust-lead loading of 5 µg/ft^2, the HUD model and Rochester multimedia model provides nearly identical estimates of the probability at or above 10 µg/dL, across the entire range of soil-lead concentration (10-4000 ppm). This is due to the similar geometric mean estimates observed in Figure 3-1b. At this floor dust-lead loading and at GSD=1.72, the estimated probabilities range from approximately 1.5% to 18% under both models as the soil-lead concentration increases.

Table F-3. Percentage of Children with Blood-Lead Concentration At or Above 10 μg/dL, as Predicted by the HUD Model for Specified Values of Environmental-Lead Levels and Under Different Estimates for GSD[1]

Interior Floor Dust-Lead Loading (μg/ft²)[2]	Soil-Lead Concentration at the Yard Perimeter (ppm)							
	10	72[3]	100	500	1000	1500	2000	4000
GSD = 1.6								
1	0.09	0.34	0.42	1.28	1.98	2.56	2.89	4.03
5	0.77	2.56	2.89	6.45	8.84	10.2	11.6	14.6
10	1.72	4.92	5.41	10.9	14.6	16.3	18.0	23.3
15	2.56	7.01	7.60	14.6	18.8	21.5	26.1	28.9
20	3.25	8.84	9.49	18.0	22.4	25.2	28.0	32.7
25	4.03	10.2	11.6	20.6	25.2	28.9	30.8	36.5
40	6.45	14.6	16.3	27.0	32.7	35.5	38.4	44.8
55	8.21	18.0	19.7	31.7	37.4	41.1	43.9	50.0
70	10.2	20.6	22.4	35.5	42.0	45.7	48.3	54.1
100	13.1	25.2	28.0	41.1	47.4	51.7	54.1	60.3
GSD = 1.72								
1	0.34	0.95	1.12	2.64	3.72	4.56	5.01	6.50
5	1.78	4.56	5.01	9.42	12.1	13.5	15.0	18.1
10	3.34	7.61	8.19	14.3	18.1	19.7	21.4	26.4
15	4.56	10.1	10.7	18.1	22.2	24.7	28.9	31.5
20	5.48	12.1	12.8	21.4	25.5	28.1	30.6	34.9
25	6.50	13.5	15.0	23.9	28.1	31.5	33.2	38.2
40	9.42	18.1	19.7	29.8	34.9	37.4	39.9	45.5
55	11.4	21.4	23.0	34.0	39.0	42.3	44.7	50.0
70	13.5	23.9	25.5	37.4	43.1	46.2	48.5	53.6
100	16.5	28.1	30.6	42.3	47.8	51.5	53.6	58.9
GSD = 1.75								
1	0.43	1.15	1.35	3.03	4.19	5.08	5.56	7.12
5	2.09	5.08	5.56	10.1	12.8	14.3	15.8	18.9
10	3.78	8.26	8.86	15.0	18.9	20.5	22.1	27.0
15	5.08	10.8	11.4	18.9	22.9	25.4	29.5	32.0
20	6.06	12.8	13.5	22.1	26.2	28.7	31.2	35.3
25	7.12	14.3	15.8	24.5	28.7	32.0	33.7	38.6
40	10.1	18.9	20.5	30.4	35.3	37.8	40.2	45.6
55	12.1	22.1	23.7	34.5	39.4	42.5	44.8	50.0
70	14.3	24.5	26.2	37.8	43.3	46.3	48.6	53.5
100	17.3	28.7	31.2	42.5	47.8	51.4	53.5	58.6

[1] Footnotes are indicated within Table F-1.

Table F-4. Percentage of Children with Blood-Lead Concentration At or Above 10 µg/dL, as Predicted by the Rochester Multimedia Model for Specified Values of Environmental-Lead Levels and Under Different Estimates for GSD[1]

Interior Floor Dust-Lead Loading (µg/ft²)[2]	Soil-Lead Concentration at the Drip Line (ppm)								
	10	72[3]	100	400	500	1000	1500	2000	4000
GSD = 1.6									
1	0.30	1.15	1.41	3.16	3.56	5.09	6.20	7.10	9.68
5	0.57	2.03	2.45	5.13	5.72	7.92	9.48	10.71	14.14
10	0.76	2.55	3.06	6.24	6.93	9.46	11.23	12.62	16.44
15	0.88	2.91	3.48	6.97	7.72	10.46	12.35	13.83	17.89
20	0.98	3.19	3.80	7.53	8.32	11.21	13.20	14.75	18.96
25	1.07	3.42	4.07	7.98	8.81	11.82	13.88	15.48	19.82
40	1.27	3.95	4.68	9.01	9.92	13.17	15.39	17.10	21.71
50	1.38	4.23	5.00	9.53	10.47	13.86	16.15	17.91	22.64
55	1.42	4.35	5.13	9.75	10.72	14.15	16.48	18.26	23.05
70	1.55	4.67	5.50	10.35	11.36	14.93	17.33	19.18	24.09
100	1.76	5.18	6.08	11.28	12.35	16.12	18.64	20.57	25.68
GSD = 1.72									
1	0.85	2.44	2.86	5.36	5.89	7.81	9.13	10.16	13.00
5	1.43	3.79	4.40	7.86	8.57	11.08	12.78	14.09	17.60
10	1.76	4.54	5.24	9.17	9.97	12.76	14.63	16.06	19.87
15	1.99	5.03	5.79	10.01	10.86	13.82	15.79	17.29	21.27
20	2.16	5.41	6.21	10.64	11.52	14.61	16.65	18.20	22.30
25	2.31	5.71	6.55	11.14	12.06	15.24	17.33	18.93	23.12
40	2.64	6.40	7.31	12.27	13.25	16.63	18.84	20.52	24.90
50	2.81	6.75	7.69	12.83	13.84	17.31	19.58	21.30	25.77
55	2.88	6.90	7.86	13.07	14.10	17.61	19.90	21.63	26.14
70	3.08	7.30	8.30	13.71	14.76	18.38	20.73	22.50	27.11
100	3.40	7.92	8.99	14.68	15.79	19.56	22.00	23.83	28.56
GSD = 1.75									
1	1.04	2.81	3.26	5.93	6.48	8.47	9.83	10.88	13.75
5	1.69	4.27	4.91	8.52	9.25	11.81	13.53	14.84	18.35
10	2.06	5.06	5.80	9.87	10.68	13.51	15.39	16.82	20.60
15	2.31	5.58	6.38	10.72	11.58	14.58	16.55	18.05	21.99
20	2.51	5.98	6.81	11.36	12.26	15.37	17.41	18.95	23.01
25	2.66	6.29	7.17	11.88	12.80	16.00	18.09	19.67	23.82
40	3.02	7.01	7.95	13.01	14.00	17.38	19.59	21.25	25.57
50	3.21	7.37	8.35	13.58	14.59	18.07	20.32	22.02	26.42
55	3.29	7.53	8.52	13.82	14.85	18.36	20.64	22.35	26.79
70	3.51	7.94	8.98	14.46	15.52	19.13	21.46	23.21	27.74
100	3.84	8.58	9.68	15.44	16.55	20.30	22.71	24.51	29.16

[1] Footnotes are indicated within Table F-2.

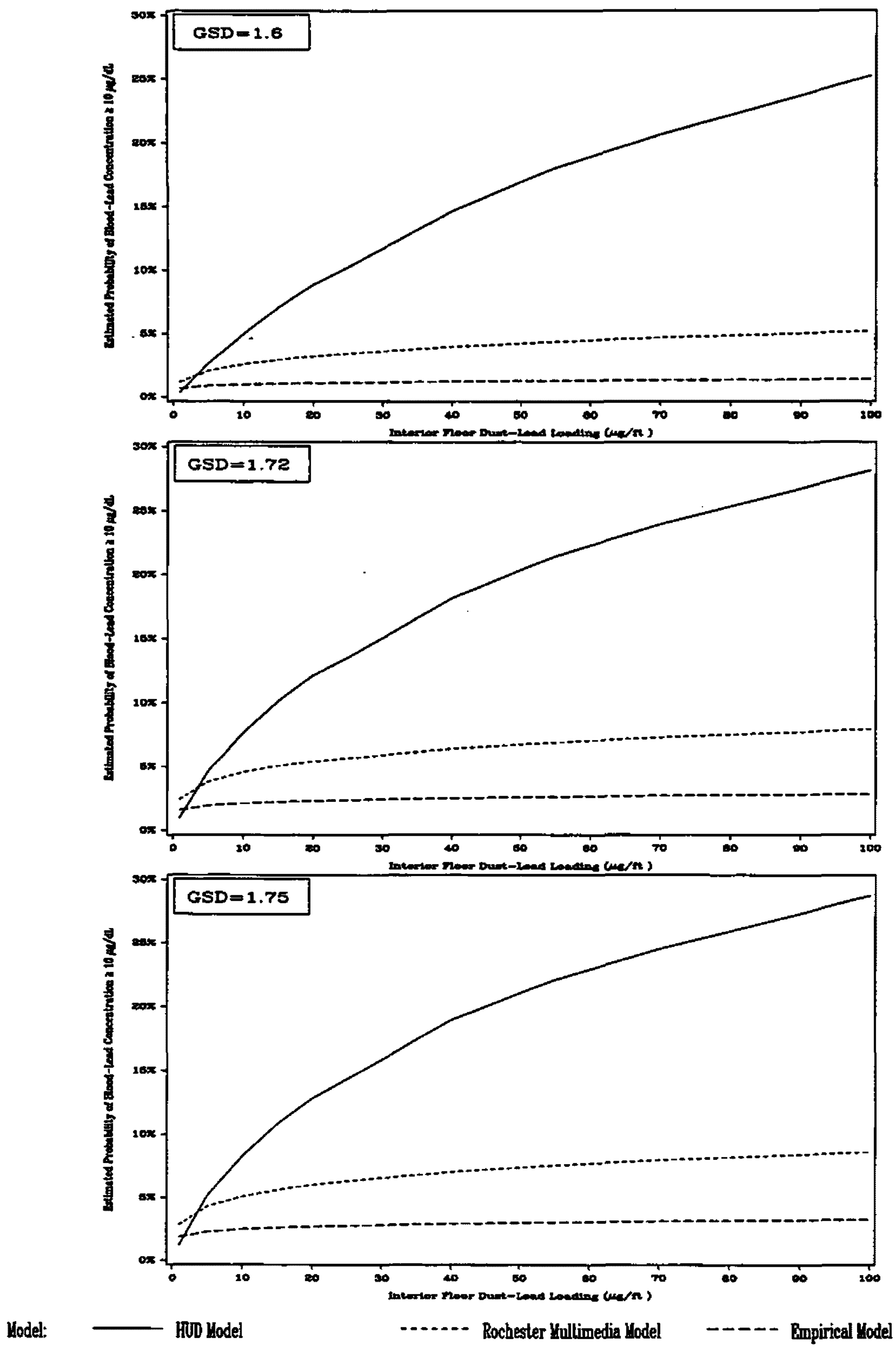

Figure F-2a. Predicted Percentage of Children with Blood-Lead Concentration At or Above 10 µg/dL vs. Floor Dust-Lead Loading (µg/ft²), Assuming Soil-Lead Concentration = 72 ppm (see footnotes to Tables F-1 and F-2)

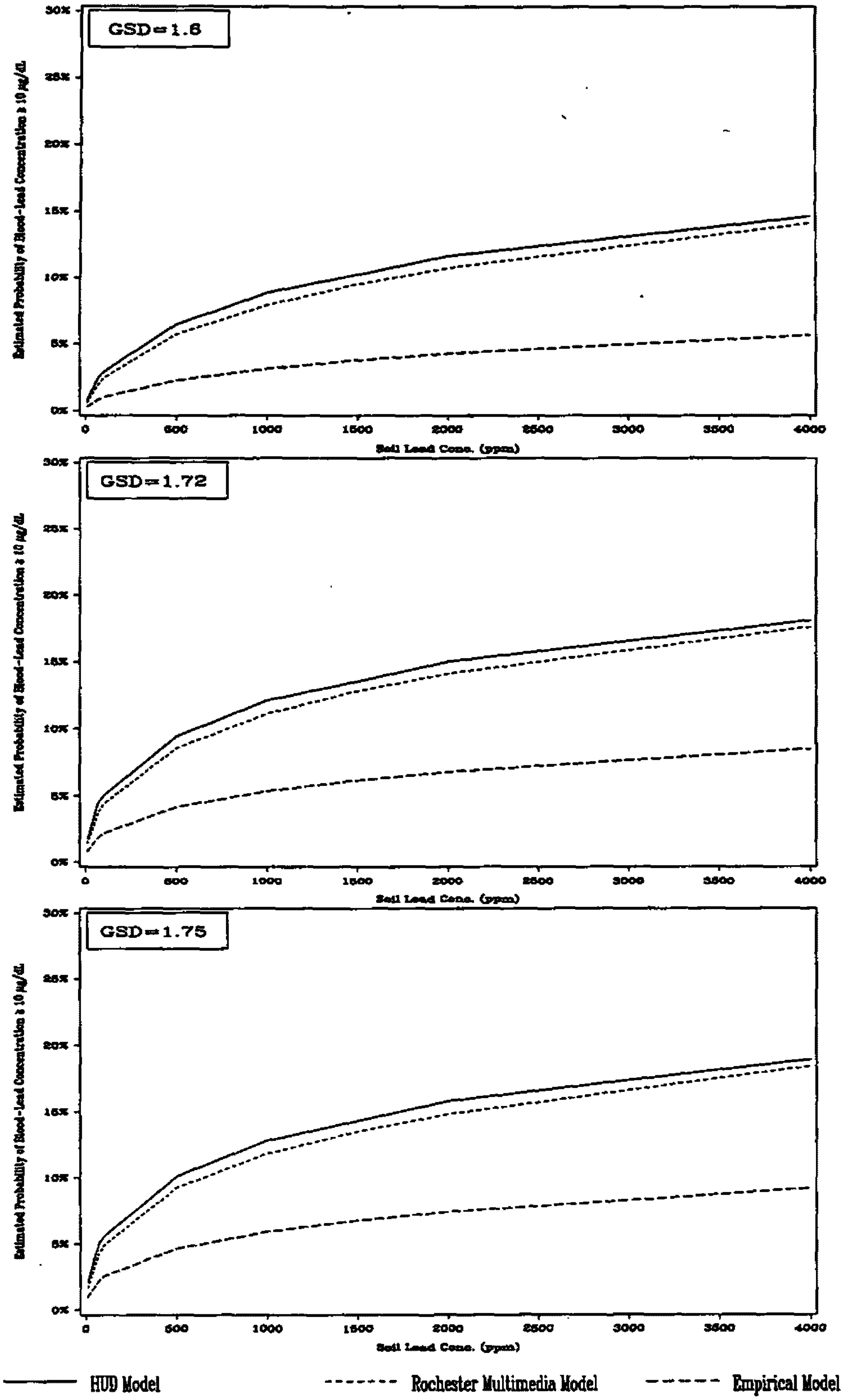

Figure F-2b. Predicted Percentage of Children with Blood-Lead Concentration At or Above 10 µg/dL vs. Soil-Lead Concentration (ppm), Assuming Floor Dust-Lead Loading = 5 µg/ft² (see footnotes to Tables F-1 and F-2)

Across Tables F-3 and F-4, the largest deviation in the estimated percentage of children with blood-lead concentration at or above 10 µg/dL between the HUD model and the Rochester multimedia model exists at the lowest soil-lead concentration (10 ppm) and the highest floor dust-lead concentration (100 µg/ft^2). Here, the HUD model estimate (16.5%) is nearly five times that under the Rochester multimedia model (3.4%) when GSD=1.72.

Table F-5 presents the predicted geometric mean blood-lead concentration and percentage of children with blood-lead concentration at or above 10 µg/dL, at the proposed §403 hazard standards for floors and soil (50 µg/ft^2 and 2000 ppm, respectively). For the Rochester multimedia model, the window sill dust-lead loading is assumed to be 27.5 µg/ft^2 (the estimated national median). At these levels, the GSD assumption has less of an impact on the predicted percentages than was seen at national median levels. However, the HUD model predicts considerably higher percentages than the other.

Table F-5. Predicted Geometric Mean Blood-Lead Concentration and Percentage of Children with Blood-Lead Concentration At or Above 10 µg/dL, at the Proposed §403 Hazard Standards for Floors and Soil (50 µg/ft^2 and 2000 ppm, Respectively) and at a Window Sill Dust-Lead Loading of 27.5 µg/ft^2 (An Estimated Median Level for the Nation)

Model	Predicted Geometric Mean Blood-Lead Concentration (µg/dL)	Predicted Percentage of Children With Blood-Lead Concentrations At or Above 10 µg/dL		
		GSD = 1.6	GSD = 1.72	GSD = 1.75
HUD Model*	9.1	42%	43%	44%
Rochester Multimedia Model	6.49	17.9%	21.3%	22.0%

* Values are interpolated from results presented in Lanphear et al., 1998. This model does not use window sill dust-lead loading at an input value.

APPENDIX G

PERFORMANCE CHARACTERISTICS ANALYSIS CITED IN THE §403 PROPOSED RULE

Battelle
. . . Putting Technology To Work

Date September 3, 1997

To Todd Holderman

From Ronald Menton and Warren Strauss

Subject Requested Analyses for WA 3-28 EPA Contract No. 68-D5-0008

Attached are two tables describing the results of analyses performed to identify example options for combined multi-media standards which achieve negative predictive values of 99, 95 and 90 percent for detecting a childhood blood-lead concentration of 10 µg/dL. The negative predictive value is defined in this analysis as the probability of a resident child in the Rochester Lead-in-Dust study having a blood-lead concentration below 10 µg/dL, given that lead-levels in residential environmental media are below the combined standard. The example standards provided in this memorandum are based on an empirical sensitivity/specificity analysis performed on a subset of 77 homes/children from the Rochester Lead-in-Dust Study. These 77 homes included measurements of children's blood-lead concentration, soil-lead concentration, uncarpeted floor and window sill dust-lead loading and the percentage of interior and exterior painted surfaces with deteriorated lead-based paint. For each home, soil-lead concentrations measured for the drip-line and play-area sampling locations were averaged to produce a yard-wide average soil-lead concentration. The sensitivity/specificity analyses focussed on all possible combinations of the following potential standards for environmental lead:

Environmental Media	Potential Standards Considered in Analysis
Uncarpeted Floor Dust-Lead Loading	50, 75, 100, 125, 150, 175, 200 and 400 µg/ft^2
Window Sill Dust-Lead Loading	800, 500, 300 and 100 µg/ft^2
Average Soil-Lead Concentration	200, 300, 400, 500, 600, 700, 900, 1000, 1500 µg/g
Maximum of Percent of Interior/Exterior Painted Surfaces with Deteriorated LBP	5, 10, 20 %

Table 1 provides the maximum lead-levels identified in each of the above four environmental media, which when combined, achieve a negative predictive value (NPV) of 99, 95 and 90 percent or above. Note that combined standards that achieve a NPV of 99% also achieve NPV's of 95% and 90%, and that combined standards that achieve a NPV of 95% also achieve a NPV of 90%.

Table 2 provides a summary of all the potential combinations of standards in the above four environmental media that achieved negative predictive values of 99, 95 and 90 percent or above. In Table 2, the negative predictive value achieved corresponds to any combination of potential standards in a row. For example, all combinations of standards of 50 - 400 µg/ft^2 for dust on uncarpeted floors, 100 - 800 µg/ft^2 for dust on window sills, 200 - 900 µg/g for average soil and 5 - 20 percent of painted surfaces having deteriorated lead-based paint resulted in negative predictive values of 99 percent or above.

Please note that the results provided in Tables 1 and 2 are based on an analysis of data from 77 homes, and that since there were relatively few homes that had environmental lead-levels below the combination of standards under consideration, the denominator for the negative predictive value estimates are small in most cases (i.e. less than 25).

Table 1. Example Options For the Maximum Combined Multi-Media Standard which Achieves a NPV of 99, 95 and 90% for Detecting a Blood-Lead Concentration of 10 µg/dL, Based on Data from the Rochester Lead-in-Dust Study.

NPV Achieved	Uncarpeted Floor Dust-Lead Standard ($\mu g/ft^2$)	Average Soil-Lead Concentration (µg/g)	Window Sill Dust-Lead Standard ($\mu g/ft^2$)	Maximum of Percent of Interior/Exterior Components with Deteriorated LBP
99%	400	900	800	20
	50	1500	500	20
95%	400	1500	500	20
90%	400	1500	800	20

Table 2. Example Options For All Combinations of Multi-Media Standards which Achieve a NPV of 99, 95 and 90% for Detecting a Blood-Lead Concentration of 10 µg/dL, Based on Data from the Rochester Lead-in-Dust Study.

NPV Achieved	Uncarpeted Floor Dust-Lead Standard ($\mu g/ft^2$)	Average Soil-Lead Concentration (µg/g)	Window Sill Dust-Lead Standard ($\mu g/ft^2$)	Maximum of Percent of Interior/Exterior Components with Deteriorated LBP
99%	400, 200, 175, 150, 125, 100, 75, 50	900, 700, 600, 500, 400, 300, 200	800, 500, 300, 100	20, 10, 5
	50	1500, 1000	500, 300, 100	20, 10, 5
95%	400, 200, 175, 150, 125, 100, 75	1500	500	20
90%	400, 200, 175, 150, 125, 100, 75	1500	800, 300, 100	20
			500, 300	10, 5
		1000	500, 300	20, 10, 5
			100	20
	50	1500, 1000	800	20, 10, 5

The options for combined multi-media standards in these tables are based on a sensitivity/specificity analysis of empirical data from 77 homes in the Rochester Lead-in-Dust Study which included measurements of children's blood-lead concentration, drip-line and play-area soil-lead concentration, uncarpeted floor and window sill dust-lead loading, and the percentage of interior and exterior painted surfaces with deteriorated lead-based paint.

APPENDIX H

REVIEW OF PUBLISHED INFORMATION ON POST-INTERVENTION WIPE DUST-LEAD LOADINGS ON FLOORS AND WINDOW SILLS

H1.0 INTRODUCTION

One goal of the §403 risk analysis was to determine how the likelihood of children with blood-lead concentrations exceeding certain thresholds (10 and 20 μg/dL) declines as a result of reducing environmental-lead levels when interventions are performed in response to §403 rules. An empirical model was used in both a pre- and post-intervention setting to predict geometric mean blood-lead concentration as a function of environmental-lead levels, including average dust-lead loadings for floors and window sills. It was assumed that pre-intervention average dust-lead loadings on floors and window sills were reduced when performing the following interventions:

- Dust cleaning (as triggered by exceeding either the floor or window sill dust-lead standards)
- Interior paint abatement
- Soil removal

For each of these interventions, the assumed post-intervention wipe dust-lead loadings are as follows:

- Floors: 40 $\mu g/ft^2$ or the pre-intervention value, whichever is smaller
- Window sills: 100 $\mu g/ft^2$ or the pre-intervention value, whichever is smaller.

Note that both assumptions are below their respective §403 standards. Post-intervention dust-lead loadings are assumed to hold for four years following a dust cleaning, 20 years following interior paint abatement, and permanently following soil removal.

Since the §403 risk analysis was performed, additional information has been identified which could be used to refine the assumptions on post-intervention wipe dust-lead loadings. This appendix examines some of that information and summarizes existing data from intervention studies to characterize pre- and post-intervention wipe dust-lead loadings.

H2.0 REVIEW OF AVAILABLE INFORMATION

According to Section 6.1.1 of the §403 risk analysis report, the post-intervention dust-lead loadings of 40 $\mu g/ft^2$ for floors and 100 $\mu g/ft^2$ for window sills were selected based on data from EPA's Comprehensive Abatement Performance (CAP) study and the Baltimore Experimental Paint Abatement study. Justification was as follows:

- Geometric mean vacuum dust-lead loadings from abated units in the CAP study were 29 $\mu g/ft^2$ for floors (187 samples) and 92 $\mu g/ft^2$ for window sills (78 samples), where the samples were collected approximately two years after paint intervention performed within the HUD Lead-Based Paint Abatement Demonstration.

- Geometric mean <u>wipe</u> dust-lead loadings in the Baltimore Experimental Paint Abatement study were 41 μg/ft^2 for floors and 103 μg/ft^2 for window sills, in 13 housing units approximately 18-42 months after complete paint intervention.

Intervention studies that contain information on pre- and post-intervention dust-lead loadings (assuming either wipe dust collection methods or a method in which the reported loadings can be converted to wipe-equivalent loadings) and that can be used to evaluate the §403 assumptions on post-intervention dust-lead loadings are identified in Table H-1. These studies were included in USEPA, 1995a, and USEPA, 1998, which contain summary information on studies available in the scientific literature whose findings could be used to make conclusions on the effectiveness of lead hazard intervention (defined as "any non-medical activity that seeks to prevent a child from being exposed to the lead in his or her surrounding environment"). A summary of key information on study design and conclusions for the studies in Table H-1 is found in Appendix H2.

When comparing dust-lead loading results across the studies in Table H-1, the following issues should be considered:

<u>Converting vacuum dust-lead loadings to wipe-equivalent loadings</u>

Two of the studies in Table H-1 used dust collection methods other than the wipe method. The Baltimore R&M study used the BRM vacuum method, while the CAP study used a cyclone vacuum specifically developed for the study. While post-intervention <u>wipe</u> dust-lead loadings are of interest here, these two studies are included in Table H-1 as previous efforts allow the vacuum dust-lead loadings to be converted to wipe-equivalent loadings. These conversions were made prior to displaying results from these two studies in this appendix.

The Baltimore R&M study collected composite dust samples using the BRM vacuum method. The conversion of BRM dust-lead loadings to wipe-equivalent loadings for the Baltimore R&M study was developed within the §403 risk analysis effort (USEPA, 1997a) and takes the following form:

<u>Floors</u>: $\text{Wipe} = (p \times 8.34 \times \text{BRM}^{0.371}) + ((1-p) \times 3.01 \times \text{BRM}^{0.227})$
<u>Window sills</u>: $\text{Wipe} = 14.8 \times \text{BRM}^{0.453}$

where Wipe is the average wipe dust-lead loading, BRM is the average BRM dust-lead loading, and p is the proportion of a composite floor-dust sample obtained from uncarpeted floors. These conversion equations were determined based on side-by-side BRM/wipe dust-lead loading data from four studies.

Dust-lead loadings for samples collected by the CAP study's cyclone vacuum were converted to wipe-equivalent loadings based on the conclusion made within the CAP study that vacuum dust-lead loadings were, on average, 1.38 times larger than wipe dust-lead loadings

Table H-1. Studies Containing Information on Pre-Intervention and Post-Intervention Dust-Lead Loadings on Floors and Window Sills, Where Wipe Collection Methods or a Method Whose Loadings Can Be Converted to Wipe-Equivalents Were Used

Study	Study Duration	Type of Interventions Considered	Type of Wipe Digestion Method	Reference(s)
Baltimore (MD) Dust Control Study	1981	Paint interventions Some units received periodic dust control	Cold HCl	Charney et al., 1983
Baltimore (MD) Experimental Paint Abatement Studies	1986-87 (Study #1) 12/91 - 01/92 (Study #2)	Paint interventions using experimental procedures, with extensive cleanup	Cold HCl	Farfel and Chisolm, 1991 Farfel et al., 1994
Baltimore (MD) Follow-up Paint Abatement Study	01/91 - 06/92	Paint interventions with extensive clean-up	Cold HCl	MDE, 1995
Baltimore (MD) Repair and Maintenance (R&M) Study	1993-95	Various types of R&M paint interventions (including cleanup, prevention of recontamination, and education)	BRM vacuum method was used	USEPA, 1996b USEPA, 1997b USEPA, 1997c
Baltimore (MD) Traditional/Modified Paint Abatement Study	1984-85	"Traditional" and "modified" paint abatements, with some cleanup.	Cold HCl	Farfel and Chisolm, 1990
Boston (MA) Interim Dust Intervention Study	05/93 - 04/95	Intervention groups received paint and/or dust intervention (low-tech). Comparison group received an outreach visit.	Cold HCl	Aschengrau et al., 1998 Mackey et al., 1996
Evaluation of the HUD Lead-Based Paint Hazard Control Grant Program (HUD Grantees) (data collected through August, 1997)	1994 - present	Wide range of interventions to reduce/eliminate lead-based paint hazards.	Heated HNO_3/H_2O_2	NCLSH and UC, 1997 NCLSH and UC, 1998
HUD Abatement Demonstration Program/EPA Comprehensive Abatement Performance (CAP) Study	1989-90 (HUD Demo) 03/92 - 04/92 (CAP Study)	Encapsulation/enclosure Various paint removal methods	Heated HNO_3/H_2O_2 (CAP Study cyclone was used in the CAP Study)	HUD, 1991 USEPA, 1996a

Table H-1. (cont.)

Study	Study Duration	Type of Interventions Considered	Type of Wipe Digestion Method	Reference(s)
Jersey City (NJ) Children's Lead Exposure and Reduction (CLEAR) Dust Intervention Study	1992-94	Biweekly dust control assistance and educational sessions	Heated HNO_3/H_2O_2	Adgate et al., 1995 Lioy et al., 1997
Paris Paint Abatement Study	01/90 - 02/92	Paint interventions with dust cleaning	Unspecified	Nedellec et al., 1995
Rochester (NY) Educational Intervention Study	08/93 - 06/94	Intervention group received direction on performing periodic dust control. Control group received educational materials only.	Heated HNO_3/H_2O_2	Lanphear et al., 1996

(USEPA, 1996a), regardless of lead level or sampling component. This conclusion was made by fitting a log-linear regression model, using an errors-in-variables approach, on lead loading data for 33 pairs of side-by-side vacuum/wipe dust samples collected within the CAP study. The model predicted vacuum dust-lead loading as a function of wipe dust-lead loading. Therefore, the conversion of vacuum dust-lead loading data from the CAP study (for both floors and window sills) involved dividing each vacuum dust-lead loading by 1.38 to obtain a wipe-equivalent loading. The estimated geometric mean wipe dust-lead loading equals the geometric mean vacuum dust-lead loading, divided by 1.38.

<u>Handling differences in wipe digestion methods</u>

The studies in Table H-1 are identified according to the type of wipe digestion method used in the analytical process. Generally, one of two categories of digestion methods was used by each study. The "heated HNO_3/H_2O_2" method, which is the method recommended in EPA's National Lead Laboratory Accreditation Program (NLLAP), allows total lead amounts in the sample to be determined. The "cold HCl" method, documented in Vostal et al., 1974, and used at the Kennedy Krieger Institute in Baltimore, MD, generally allows only "bioavailable" lead amounts to be measured in the sample. Therefore, in order to make wipe dust-lead loadings comparable across all studies in Table H-1, it is necessary to adjust the "bioavailable" lead loadings that are reported in the studies that used the "cold HCl" digestion method to reflect total lead amounts. Appendix A of USEPA, 1997a, provided a means by which this adjustment can be made:

$$T = B^{1.1416}$$

where T is the total dust-lead loading, and B is the "bioavailable" dust-lead loading. This adjustment was developed by fitting a log-linear regression model (with no intercept term) on existing uncarpeted floor dust-lead loading data that were collected in a pilot study that investigated how dust-lead loadings changed across five different sampling and analysis methods. (See USEPA, 1997a, for details.)

In this appendix, summary statistics for studies labeled in Table H-1 as utilizing the "cold HCl" wipe digestion method were calculated on dust-lead loadings that were adjusted by the method in the previous paragraph. This implies taking geometric means calculated on the study data to the 1.1416 power.

Considering different intervention methods across studies

As seen in the second column of Table H-1, the studies utilized different intervention approaches. The HUD Grantees evaluation program is the most widely-encompassing of the studies, containing dust-lead loading data at up to 12 months post-intervention for floors and window sills in over 500 housing units as measured by 14 Grantees across the country. Therefore, the impact of intervention activities on dust-lead loading will likely vary considerably across these studies. Furthermore, caution should be used in considering the results of certain studies, such as the educational intervention studies, when the aim is to evaluate the effect of performing highly-intensive dust and paint abatements on dust-lead loading.

H3.0 RESULTS

For eight studies in Table H-1 that measured and documented post-intervention dust-lead loadings and which considered paint and/or dust interventions (i.e., not just educational interventions), Tables H-2 and H-3 provide summaries of the measured dust-lead loadings from these studies, both prior to intervention (if available) and at specified time points following the interventions, for floors and window sills, respectively. Summaries are presented according to study group within each study. These tables contain geometric mean dust-lead loadings for all studies but the HUD Grantees evaluation, whose references provided only median dust-lead loadings. Note that not all studies in these tables provided information on pre-intervention dust-lead loadings. Also, as discussed in the previous chapter, the measured dust-lead loadings in the Baltimore R&M study and the CAP study have been converted from vacuum to wipe-equivalent loadings, and dust-lead loadings in studies using the "cold HCl" wipe digestion method have been adjusted to reflect total lead loadings, prior to preparing the summaries in Tables H-2 and H-3.

More detailed dust-lead loading summaries are provided in the tables in Appendix H3. These tables include the information in Tables H-2 and H-3, along with sample sizes associated with the summaries, 95% confidence intervals for selected estimates, and reported differences in dust-lead loadings from pre-intervention which were measured in the Paris Paint Abatement study and the Rochester Educational Intervention Study.

Table H-2. Summaries of Pre- and Post-Intervention Floor Dust-Lead Loadings from Studies Evaluating Paint and/or Dust Interventions

Study	Study Group	Pre-Intervention Floor Dust-Lead Loadings[1] ($\mu g/ft^2$)	Post-Intervention Floor Dust-Lead Loadings[1]	
			Time Following Intervention	Summary Value ($\mu g/ft^2$)
Baltimore Experimental Paint Abatement Studies[2]	Study 1 (6 homes)	1261	Immediately	259
			6-9 Months	99
	Study 2 (13 homes)	556	Immediately	20
			1.5 - 3.5 Years	69
Baltimore Follow-up Paint Abatement Study[2]	6-Month Follow-up		Immediately	47
			5-7 Months	22
	12-Month Follow-up		Immediately	41
			10-14 Months	20
	19-Month Follow-up		Immediately	24
			14-24 Months	36
Baltimore R&M Study[3]	All Occupied Units	40.9	Immediately	52.5
			2 Months	40.2
			6 Months	26.5
			12 Months	27.1
			18 Months	24.8
			24 Months	24.1
			48 Months	8.4
	Previously-Abated Units	45.6	6 Months	41.1
			12 Months	39.8
			18 Months	37.3
			24 Months	33.0
	Units Slated for R&M Intervention	58.6	Immediately	52.5
			2 Months	40.2
			6 Months	36.3
			12 Months	39.9
			18 Months	33.3
			24 Months	35.0
	Modern Urban Units	10.0	6 Months	8.1
			12 Months	7.3
			18 Months	7.8
			24 Months	7.1
			48 Months	8.4
Baltimore Traditional/ Modified Paint Abatement Study[2]	Traditional	549	Immediately	4033
			6 Months	714
	Modified	642	Immediately	1626
			6 Months	714

Table H-2. (cont.)

Study	Study Group	Pre-Intervention Floor Dust-Lead Loadings[1] (µg/ft²)	Post-Intervention Floor Dust-Lead Loadings[1]	
			Time Following Intervention	Summary Value (µg/ft²)
Boston Interim Dust Intervention Study[2]	Automatic Intervention	33.2	6 Months	23.9
	Randomized Intervention	37.3	6 Months	31.4
HUD Grantees	All Grantees	19	Immediately	17
			6 Months	14
			12 Months	14
	Baltimore	41	Immediately	18
			6 Months	42
			12 Months	41
	Boston	24	Immediately	54
			6 Months	16
			12 Months	18
	Massachusetts	24	Immediately	20
			6 Months	11
			12 Months	9
	Milwaukee	14	Immediately	15
			6 Months	10
			12 Months	10
	Minnesota	18	Immediately	18
			6 Months	18
			12 Months	18
	Rhode Island	26	Immediately	7
			6 Months	6
			12 Months	6
	Vermont	28	Immediately	17
			6 Months	21
			12 Months	21
	Wisconsin	9	Immediately	8
			6 Months	6
			12 Months	5
CAP Study[4]	Abated Units		2 Years	21.0
Jersey City CLEARS	Intervention Group	22	12 Months	15

[1] Values are geometric means except for the HUD Grantees studies, where values are medians.
[2] Results are adjusted to reflect total dust-lead loadings by exponentiating the "bioavailable" dust-lead loadings as reported in the study to the 1.1416 power.
[3] Results for the Baltimore R&M Study are converted from BRM dust-lead loadings to wipe-equivalent loadings.
[4] Results for the CAP study are converted from CAPS cyclone dust-lead loadings to wipe-equivalent loadings.

Table H-3. Summaries of Pre- and Post-Intervention Window Sill Dust-Lead Loadings from Studies Evaluating Paint and/or Dust Interventions

Study	Study Group	Pre-Intervention Sill Dust-Lead Loadings[1] (µg/ft²)	Post-Intervention Sill Dust-Lead Loadings[1]	
			Time Following Intervention	Summary Value (µg/ft²)
Baltimore Experimental Paint Abatement Studies[2]	Study 1 (6 homes)	15215	Immediately	737
			6-9 Months	958
	Study 2 (13 homes)	2784	Immediately	19
			1.5 - 3.5 Years	199
Baltimore Follow-up Paint Abatement Study[2]	6-Month Follow-up		Immediately	50
			5-7 Months	71
	12-Month Follow-up		Immediately	50
			10-14 Months	41
	19-Month Follow-up		Immediately	50
			14-24 Months	147
Baltimore R&M Study[3]	All Occupied Units	356.2	Immediately	185.4
			2 Months	241.4
			6 Months	138.2
			12 Months	136.2
			18 Months	135.1
			24 Months	117.5
			48 Months	37.1
	Previously-Abated Units	163.5	6 Months	107.4
			12 Months	116.0
			18 Months	89.1
			24 Months	97.6
	Units Slated for R&M Intervention	778.4	Immediately	185.4
			2 Months	241.4
			6 Months	247.0
			12 Months	237.6
			18 Months	246.8
			24 Months	204.9
	Modern Urban Units	45.6	6 Months	41.7
			12 Months	40.0
			18 Months	40.5
			24 Months	34.8
			48 Months	37.1
Baltimore Traditional/ Modified Paint Abatement Study[2]	Traditional	3708	Immediately	11460
			6 Months	4360
	Modified	5209	Immediately	1496
			6 Months	4662
Boston Interim Dust Intervention Study[2]	Automatic Intervention	787	6 Months	210
	Randomized Intervention	205	6 Months	110

Table H-3. (cont.)

Study	Study Group	Pre-Intervention Sill Dust-Lead Loadings[1] ($\mu g/ft^2$)	Post-Intervention Sill Dust-Lead Loadings[1]	
			Time Following Intervention	Summary Value ($\mu g/ft^2$)
HUD Grantees	All Grantees	258	Immediately	52
			6 Months	97
			12 Months	90
	Baltimore	1191	Immediately	49
			6 Months	87
			12 Months	68
	Boston	174	Immediately	53
			6 Months	48
			12 Months	49
	Massachusetts	328	Immediately	32
			6 Months	77
			12 Months	50
	Milwaukee	264	Immediately	84
			6 Months	231
			12 Months	217
	Minnesota	266	Immediately	66
			6 Months	86
			12 Months	77
	Rhode Island	314	Immediately	18
			6 Months	87
			12 Months	85
	Vermont	147	Immediately	21
			6 Months	60
			12 Months	40
	Wisconsin	150	Immediately	22
			6 Months	37
			12 Months	51
CAP Study[4]	Abated Units		2 Years	66.4
Jersey City CLEARS	Intervention Group	75	12 Months	24

[1] Values are geometric means except for the HUD Grantees studies, where values are medians.
[2] Results are adjusted to reflect total dust-lead loadings by exponentiating the "bioavailable" dust-lead loadings as reported in the study to the 1.1416 power.
[3] Results for the Baltimore R&M Study are converted from BRM dust-lead loadings to wipe-equivalent loadings.
[4] Results for the CAP study are converted from CAPS cyclone dust-lead loadings to wipe-equivalent loadings.

Floor dust-lead loadings

Table H-2 contains post-intervention floor dust-lead loading summaries for 24 study groups, including two control groups from the Baltimore R&M study and a total of nine groups from the HUD Grantees evaluation.

Eighteen study groups in Table H-2 contain information on dust-lead loading measurements immediately after intervention. Of these 18 groups, 10 had geometric mean or median dust-lead loadings ranging from 7-24 $\mu g/ft^2$ immediately after intervention. Eight of these 10 groups were from the HUD Grantees evaluation, whose pre-intervention median dust-lead loadings were no higher than 41 $\mu g/ft^2$. Eight of the 18 groups had geometric mean or median dust-lead loadings above 40 $\mu g/ft^2$ immediately after intervention.

Among the nine study groups in the HUD Grantees evaluation, seven groups had median dust-lead loadings that remained constant or steadily declined to below 20 $\mu g/ft^2$ for up to 12 months post-intervention. The other two study groups had median loadings increase to approximately pre-intervention levels over this 12-month period. In addition, the CAP study, the Baltimore Follow-up Paint Abatement study, the Baltimore R&M study, and Boston Interim Dust Intervention study, and the CLEARS suggest that geometric mean dust-lead loadings of below 40 $\mu g/ft^2$ can be observed for up to two years post-intervention. Only in study #1 of the Baltimore Experimental Paint Abatement studies and the Baltimore Traditional/Modified Paint Abatement study did geometric mean dust-lead loadings exceed 40 $\mu g/ft^2$ at approximately six months post-intervention; however, pre-intervention levels were higher than in the other studies.

Window sill dust-lead loadings

The same 24 study groups represented in Table H-2 also are included in Table H-3, where post-intervention window sill dust-lead loading summaries are presented. Results in Table H-3 indicate that post-intervention window sill dust-lead loadings are generally higher (up to double the value) than those for floors. The post-intervention geometric means (or medians) range from 18 $\mu g/ft^2$ to over 11,000 $\mu g/ft^2$.

As in Table H-2, 18 study groups in Table H-3 contain information on dust-lead loading measurements immediately after intervention. In the nine study groups of the HUD Grantees evaluation, the three groups of the Baltimore Follow-up Paint Abatement study, and study #2 of the Baltimore Experimental Paint Abatement studies, geometric mean or median dust-lead loadings immediately after intervention were below 100 $\mu g/ft^2$ (range: 18-84 $\mu g/ft^2$). In particular, study #2 of the Baltimore Experimental Paint Abatement studies saw a substantial decline in the geometric mean from pre-intervention (2,784 $\mu g/ft^2$) to immediately post-intervention (19 $\mu g/ft^2$). The remaining five study groups (study #1 of the Baltimore Experimental Paint Abatement studies, and study groups from the Baltimore R&M study and the Baltimore Traditional/Modified Paint Abatement study) had geometric mean dust-lead loadings exceeding 180 $\mu g/ft^2$ immediately post-intervention, but these groups had geometric mean pre-intervention dust-lead loadings above 300 $\mu g/ft^2$.

Except for the Milwaukee grantee, the study groups within the HUD Grantees evaluation had median window sill dust-lead loadings below 100 µg/ft^2 for up to 12 months post-intervention. Only two grantees (Boston and Wisconsin) did not have a decline in median window sill dust-lead loadings over the 12-month period.

In addition to the HUD Grantees evaluation, geometric mean window sill dust-lead loadings remain below 100 µg/ft^2 for up to 12 months post-intervention in the Baltimore Follow-up Paint Abatement study, the CAP study, and the CLEARS (Table H-3). However, in studies such as the Baltimore R&M study, the Baltimore Traditional/Modified Paint Abatement study, the Baltimore Experimental Paint Abatement studies, and the Boston Interim Dust Intervention study, geometric mean dust-lead loadings remain above 100 µg/ft^2 over time. In addition, the 19-month follow-up study group within the Baltimore Follow-up Paint Abatement study and the Baltimore Experimental Paint Abatement studies suggest that geometric mean dust-lead loadings can dip below 100 µg/ft^2 immediately after intervention, but then increase substantially after one year or so.

The summaries in Tables H-2 and H-3 are calculated across housing units in specified study groups. With the lack of results for individual housing units and the absence of variability estimates associated with these summaries, these summaries do not necessarily indicate what may be occurring in specific units (such as those housing units that see little, if any, change from pre- to post-intervention). Additional information on results within housing units should also be considered if such information is available.

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APPENDIX H2

INFORMATION ON THE INTERVENTION STUDIES INCLUDED IN TABLE H-1

Baltimore (MD) Dust Control Study

- Conducted in 1981 to assess whether lead-based paint abatement followed by periodic dust control would be more effective in reducing blood-lead concentration than performing only lead-based paint abatement.

- The study targeted housing units containing lead-based paint and children aged 15-72 months of age with at least two confirmed blood-lead concentration measurements between 30-49 µg/dL.

- Two groups of housing units (a control group of 35 homes and an experimental group of 14 homes) underwent lead-based paint abatement which entailed removing all peeling lead-containing interior and exterior paint from the residence. In addition, all child accessible surfaces (below 1.2 m) which may be chewed on were covered or rendered lead-free. No extensive clean-up procedures were required following the abatements.

- The experimental group received periodic dust-control (twice-monthly visits by a dust-control team) involving wet-mopping all rooms in the residence where dust-lead loadings in an initial survey exceeded 100 $\mu g/ft^2$.

- In the experimental group, dust samples were collected from all areas within the residence where the child spent time. The samples were collected with alcohol-treated wipes within a 1 ft^2 area of floor or from the entire window sill. The samples were collected at recruitment and both before and after each dust-control measure was performed.

Baltimore (MD) Experimental Paint Abatement Studies

- Studies to demonstrate and evaluate experimental lead-based paint abatement practices developed in response to the inadequacies uncovered in the Baltimore (MD) Traditional/Modified Paint Abatement Study.

- The experimental practices called for floor-to-ceiling abatement of all interior and exterior surfaces where lead content of the paint exceeded 0.7 mg/cm^2 by XRF or 0.5% by weight by wet chemical analysis. Several methods were tested, including encapsulation, off-site and on-site stripping, and replacement. The abatements took place either in unoccupied dwellings or the occupants were relocated during the abatement process. Lead-contaminated dust was contained and minimized during the abatement, and extensive clean-up activities included HEPA vacuuming and off-site waste disposal. In addition, extensive worker training and protection were provided.

- One study involving 6 housing units (poorly-maintained, had multiple lead-based paint hazards, built in the 1920s) received abatements from 10/86-1/87 as part of a pilot study examining the experimental procedures. Four units were vacant, and two contained lead-poisoned children. This study evaluated short-term abatement efficacy (up to 9 months).

- Dust samples from the 6 housing units were collected immediately before abatement, during abatement, after the final clean-up, and at 1, 3, and 6-9 months following abatement.

- Another study which evaluated longer-term abatement efficacy (1.5-3.5 years) involved 13 occupied housing units which received experimental abatements from 1988-1991 by local pilot projects.

- Dust samples from the 13 housing units were collected from 12/91 - 01/92 at the same locations, where possible, that had been sampled pre- and immediately post-abatement.

- Alcohol-treated wet wipes were used to collect dust samples.

Baltimore (MD) Follow-up Paint Abatement Study

- Paint interventions (encapsulation, off-site and on-site stripping, and replacement) were performed (from floor to ceiling) on all interior and exterior surfaces where lead content of paint exceeded 0.7 mg/cm^2 by XRF or 0.5% by weight by wet chemical analysis. Abatements took place in unoccupied dwellings or after occupants were relocated.

- Lead-contaminated dust was contained and minimized during the abatement.

- Extensive clean-up activities (including HEPA vacuuming and off-site waste disposal) followed the abatement to ensure clearance. Clearance levels for floors, window sills, and window wells were set at 200 $\mu g/ft^2$, 500 $\mu g/ft^2$, and 800 $\mu g/ft^2$, respectively.

- Wipe dust-lead loading samples were taken upon clearance and at approximately 6, 12, and 19 months post-intervention from floors, window sills, and window wells in rooms where the child spent time.

- By 19 months post-intervention, only 5% of the homes were above clearance for floors, while 42% and 47% of the homes were above clearance levels for window sills and window wells, respectively.

Baltimore (MD) Repair & Maintenance (R&M) Study

- Study begun in 1993 to measure the short-term (2 to 6 months) and long-term (12 to 24 months) changes in dust-lead loadings and concentrations and in children's blood lead concentrations associated with conducting R&M interventions, and to make comparisons with houses that had undergone previous comprehensive abatement, as well as a group of modern urban houses.

- Three types of dwellings were recruited in this study: 16 dwellings that were previously abated (in 1988-1992), 75 dwellings slated to receive R&M interventions, and 16 modern urban dwellings (assumed to be free of lead-based paint).

- The 75 R&M dwellings were older (mostly pre-1940), low-income dwellings which were divided into three equal groups according to the intervention performed in this study; the R&M-I group had low-level interventions (wet scraping, limited repainting, wet cleaning with TSP, HEPA vacuuming, placing an entryway mat, exterior surface stabilization, cleaning supplies and education to residents), the R&M-II group had intermediate-level interventions (R&M-I interventions plus treatments to floors, windows, and doors to reduce abrasion), and the R&M-III group had high-level interventions (R&M-II interventions plus trim replacement and encapsulation). The remaining dwellings acted as control dwellings.

- The BRM vacuum method was used to collect dust samples in this study (a modified HVS_3 cyclone collector). Floor and window sill dust samples were composites across multiple rooms. The environmental sampling design was as follows:

	Type of Data [1]							
	Blood		Dust		Soil		Water	
Campaign	RM [2]	Control [3]	RM	Control	RM	Control	RM	Control
Initial	√a	√	√	√	√	√	√a	√
Immediate Post-R&M	√		√		√		√b	
2 Months Post-R&M	√		√					
6 Months Post-R&M	√	√	√	√	√	√	√	√
12 Months Post-R&M	√	√	√	√				
18 Months Post-R&M	√	√	√	√	√	√	√	√
24 Months Post-R&M	√	√	√	√				

1. A '√' indicates that the data were collected for all R&M groups or all control groups. Symbol '√a' indicates that data collected only for R&M I and II groups, and '√b' only for R&M II and III.
2. RM denotes the component including three R&M groups: R&M I, R&M II and R&M III.
3. Control denotes the component including two control groups: Previously Abated and Modern Urban.

Baltimore (MD) Traditional/Modified Paint Abatement Study

- Conducted from 1984-1985 to evaluate the health and environmental impact of "traditional" and "modified" Baltimore practices for abating lead-based paint.

- The study contained housing units with multiple interior surfaces coated with lead-based paint and containing at least one child with a blood-lead concentration exceeding 30 µg/dL.

- "Traditional" abatements (conducted in 53 housing units) addressed deteriorated paint on surfaces up to four feet from the floor, and all hazardous paint on accessible surfaces which may be chewed on. Paint with a lead content greater than 0.7 mg/cm^2 by XRF or 0.5% by weight by wet chemical analysis was denoted hazardous. Open-flame burning and sanding techniques were commonly used, the abated surfaces were not repainted, and clean-up typically entailed, at most, dry sweeping.

- "Modified" abatements (conducted in 18 housing units) included the use of heat guns for paint removal and the repainting of abated surfaces. Furnishings were protected during abatement. In addition, clean-up efforts were conducted that involved wet-mopping with a high phosphate detergent, vacuuming with a standard shop vacuum, and off-site disposal of debris. In addition, worker training, protection, and supervision were provided.

- Neither traditional nor modified abatements considered window wells.

- Dust samples were obtained using a alcohol-treated wipe within a defined area template (1 ft^2).

- Increased dust-lead loadings were measured immediately following traditional abatements (usually within two days) on or in close proximity to abated surfaces. Dust-lead levels measured after modified abatements were also higher than pre-abatement levels, but not to the extent seen for traditional practices. At six months post-abatement, PbD levels were comparable to, or greater than, their respective pre-abatement loadings in both study groups.

- Despite the implementation of improved practices, modified abatements, like traditional abatements, did not result in any long-term reductions of levels of lead in house dust. In addition, the activities further elevated blood-lead concentrations.

Boston (MA) Interim Dust Intervention Study

- Children under 4 years of age with modestly-elevated blood-lead concentration (11-24 µg/dL) and living in homes containing lead-based paint on at least two window sills or wells were targeted for participation. Lead hazard reduction activities were not previously conducted in these homes.

- Units with severe household lead hazards (i.e., paint chips on floors, large amounts of loose dust or paint chips in window wells, or holes larger than one inch wide in walls containing lead-based paint) were placed into an "automatic intervention" group (n=22).

- Remaining units were randomly assigned to a "randomized intervention" group (n=22) or a "randomized comparison" group (n=19).

- Units in the two intervention groups received a one-time paint and/or dust intervention. The intervention was considered "low-technology" and consisted of HEPA vacuuming all window well, window sill, and floor surfaces; washing window well and window sill surfaces with a tri-sodium phosphate (TSP) and water solution; repairing holes in walls; and re-painting window well and window sill surfaces to seal chipping or peeling paint. These units also received outreach and educational information including a demonstration of effective housekeeping techniques and monthly reminders with instructions to wash hard surface floors, window sills and wells with a TSP and water solution at least twice a week.

- The "randomized comparison" group received only the outreach visit, in which the home was visually assessed for lead hazards and the family was educated about the causes and prevention of lead poisoning. They were also provided with cleaning instructions and a free sample of TSP cleaning solution.

- 16 study units had permanent lead-based paint hazard remediation performed outside of the study protocol during the 6-month follow-up period. It is uncertain whether data for these units were treated differently in the study as a result.

- Dust samples were collected from floors, window sills, and window wells at baseline and 6 months post-intervention in all units, and at one month post-intervention for the two intervention groups. However, results were not reported for the one-month post-intervention campaign.

- Dust, soil, and water samples were analyzed using atomic absorption spectrophotometry (AAS). The detection limit for dust-lead loading results was 30 $\mu g/ft^2$.

- At 6 months post-intervention, geometric mean floor dust-lead loadings had decreased slightly for both intervention groups and increased in the comparison group. Geometric mean window sill dust-lead loadings decreased in all three groups, and geometric mean window well dust-lead loadings decreased for both intervention groups, but remained the same for the comparison group. None of the changes in dust-lead loadings was statistically significant.

Evaluation of the HUD Lead-Based Paint Hazard Control Grant Program (HUD Grantees)

- A formal evaluation of this ongoing study is being conducted to determine the effectiveness of various abatement methods used by State and local governments (who are HUD grantees) to reduce lead-based paint hazards in housing.
- Data collection began in 1994 and is expected to continue through 1999.
- Enrollment criteria varied among the different grantees and included targeting high-risk neighborhoods, homes with a lead-poisoned child, and unsolicited applications.
- Grantees were given the flexibility to select the type and intensity of the lead treatments for any particular unit. The intensity of an intervention is reported by location (interior, exterior, or site) and consists of a number representing the type of intervention performed in that location. The interventions range from taking no action, to a simple cleaning, to window replacement or full lead-based paint abatement. Some interim controls on soil (e.g., cover), as well as soil removal, were also performed.
- The grantees followed the same sampling protocols when collecting environmental samples (including dust using wipe techniques) and used standard forms developed specifically for the evaluation.
- Dust samples are collected from occupied housing units at four times during the study: at pre-intervention, immediately after intervention, and at 6 and 12 months following intervention. Nine of the 14 grantees participating in this evaluation are also collecting data at 24 and 36 months following intervention (these data have not yet been collected).

HUD Abatement Demonstration Program/
EPA Comprehensive Abatement Performance (CAP) Study

- The FHA portion of the HUD Abatement Demonstration Program ("HUD Demo") was conducted to estimated the comparative costs of alternative methods of lead-based paint abatement, to assess the efficacy of these methods, and to confirm the adequacy of worker protection safeguards during abatement.
- In the HUD Demo, lead-based paint abatements were performed in 172 HUD-owned, single-family properties located in seven cities across the country.
- Wipe dust samples were collected immediately following intervention and cleaning in the HUD Demo to evaluate whether lead levels were below 200 $\mu g/ft^2$ for floors and 500 $\mu g/ft^2$ for window sills. Repeated iterations of cleaning and dust sampling were performed if additional cleaning was deemed necessary.
- The CAP study was a follow-up to the HUD Demo performed in Denver, CO. The objectives of the CAP study were to assess the long-term efficacy of two primary

abatement methods (encapsulation/enclosure and removal methods), to characterize lead levels in dust and soil in unabated homes and homes abated by different methods, to investigate the relationship between household dust-lead and lead from other sources (i.e., soil and air ducts), and to compare dust-lead loading results from cyclone vacuum sampling and wipe sampling protocols.

- The CAP study collected approximately 30 dust and soil samples at each of 52 occupied houses in Denver. Of these houses, 39 had lead-based paint abatements performed approximately two years earlier as part of the HUD Demo. The remaining 17 houses were considered within the HUD Demo, but were found to be free of lead-based paint and therefore had no abatements performed.

- The CAP study used a cyclone vacuum for collecting dust samples, where this vacuum was designed especially for this study. Dust samples were collected from the floor perimeter, window sills, window wells, entryway floors, and air ducts in either two or three rooms. Some wipe dust samples were also collected to make comparisons between wipe and vacuum dust-lead loadings.

- For window sills within 10 houses, pre-abatement dust-lead loadings and loadings measured during the CAP study both averaged between 175-200 $\mu g/ft^2$ (i.e., there was no evidence of significant differences between pre- and post-intervention dust-lead loadings). However, no adjustment was made between the wipe and vacuum methods used in pre- and post-intervention, respectively. A similar comparison between pre- and post-intervention dust-lead loadings for floors was not possible due to a lack of sufficient pre-intervention data.

- Abatements were found to be effective in that no significant difference in dust-lead loadings were observed between abated and unabated units in the CAP study (with the exception of dust from air ducts).

Jersey City (NJ) Children's Lead Exposure and Reduction (CLEAR) Dust Intervention Study

- Children under 3 years of age and at risk for elevated blood-lead concentration were targeted for participation.

- Lead hazard intervention consisted of biweekly assistance with home dust control (which included wet mopping of floors, damp-sponging of walls and horizontal surfaces, and HEPA vacuuming) and a series of educational sessions about lead. The cleaning teams provided the education during the course of their visits and mainly focused on teaching the caretakers how to clean the home.

- Dust-wipe samples were collected from uncarpeted floors in the kitchen and the floor of one other room frequented by the enrolled child.

- This analysis indicated that a thorough cleaning program reduced the geometric mean of the dust and lead loading and found that 68%, 75%, and 81% of the Lead Group (Study) homes had a reduction in lead loading on the kitchen floors, bedroom floors, and window sills, respectively.

Paris Paint Abatement Study

- Children less than 6 years of age, identified as severely lead-poisoned, and living in homes with lead-based paint were targeted for participation.

- A one-time paint intervention was performed, consisting of chemical stripping with caustic products, encapsulation (consisting of covering the toxic paint with coating material which prevents the dispersion of chips and particles into the home), replacement of antiquated elements and paint coatings of lead-based paints, and a final dust cleaning. Chemical stripping, using Peel Away™, was used on 52% of the items abated, a combination of stripping and encapsulation was used on 36% of the items abated, and a combination of encapsulation and replacement was used on 12% of the abated items. Families were relocated during abatement.

- Dust samples were collected in 29 homes at baseline, during the intervention, and at 1 to 2 months, 3 to 6 months, and 7 to 12 months post-intervention. Dust sampling was done by wiping the floor 1 meter from the wall, over an area of 30x30 cm^2, with a paper towel impregnated with alcohol.

- For 11 homes having an initial dust-lead loading greater than 92.9 $\mu g/ft^2$, median decreases were 144 $\mu g/ft^2$ at 1 to 2 months follow up and 157 $\mu g/ft^2$ at 3 to 6 months post-intervention.

- By 6 to 28 months post-intervention, the maximum dust-lead loadings were less than 92.9 $\mu g/ft^2$ for 40 out of 45 households.

Rochester (NY) Educational Intervention Study

- Included 104 of the 205 children in the Rochester Lead-in-Dust study, aged 12-31 months at enrollment, with low to moderate blood-lead concentration. Households were randomly assigned to an intervention or control group.

- Aim of the study was to determine the effectiveness of simple dust control by household members as a means of reducing children's blood-lead concentration.

- A trained interviewer visited families assigned to the intervention group. The interviewer stressed the importance of dust control as a means of reducing lead exposure and provided the household with cleaning supplies (paper towels, spray bottles and Ledisolv, a detergent developed specifically for lead contaminated house dust). Families were instructed to clean the entire house once every three months, interior window sills, window wells and floors near windows once every month, and carpets once a week with a vacuum cleaner, if available.

- For families assigned to the control group, only a brochure was provided containing information about lead poisoning and its prevention.

- Dust samples (using a K-mart brand of baby wipes) were collected at the time of the home visit (baseline) and at seven months following the visit. Locations of dust samples included entryway floors and the kitchen, as well as from the floors, interior window sills and window wells of the child's principal play area.

APPENDIX H3

DETAILED SUMMARY TABLES

Table H3-1. Summary of Floor Dust-Lead Loadings, Under Wipe Dust Sampling Techniques, at Pre- and Post-Intervention

Name of Study	Group of Housing Units Within the Study	Pre-Intervention Floor Dust-Lead Loadings			Post-Intervention Floor Dust-Lead Loadings				Difference from Pre-Intervention			
		N	Type of Statistic[1]	Value of Statistic (μg/ft²)	Time Following Intervention	N	Type of Statistic[1]	Value of Statistic (μg/ft²)	Time Following Intervention	N	Type of Statistic[1]	Value of Statistic (μg/ft²)
Baltimore Experimental Paint Abatement Studies[2]	Study 1 (6 homes)	70	GM (95% CI)	1261 (908, 1761)	Immediately	70	GM (95% CI)	259 (196, 366)				
					6-9 Months	63	GM (95% CI)	99 (79, 136)				
	Study 2 (13 homes)	42	GM (95% CI)	556 (289, 1074)	Immediately	47	GM (95% CI)	20 (9.8, 40)				
					1.5 - 3.5 Years	71	GM (95% CI)	69 (40, 125)				
Baltimore Follow-up Paint Abatement Study[2]	6-Month Follow-up				Immediately Following Clearance	29	GM (95% CI)	29 (20,41)				
					5-7 Months		GM (95% CI)	22 (15, 31)				
	12-Month Follow-up				Immediately Following Clearance	27	GM (95% CI)	41 (25, 63)				
					10-14 Months		GM (95% CI)	20 (15, 29)				
	19-Month Follow-up				Immediately Following Clearance	22	GM (95% CI)	24 (14, 38)				
					14-24 Months		GM (95% CI)	36 (20, 63)				

Table H3-1. (cont.)

Name of Study	Group of Housing Units Within the Study	Pre-Intervention Floor Dust-Lead Loadings			Post-Intervention Floor Dust-Lead Loadings				Difference from Pre-Intervention			
		N	Type of Statistic[1]	Value of Statistic (μg/ft²)	Time Following Intervention	N	Type of Statistic[1]	Value of Statistic (μg/ft²)	Time Following Intervention	N	Type of Statistic[1]	Value of Statistic (μg/ft²)
Baltimore R&M Study[3]	All Occupied Units	90	GM	40.9	Immediately	37	GM	52.5				
					2 Months	37	GM	40.2				
					6 Months	66	GM	26.5				
					12 Months	66	GM	27.1				
					18 Months	64	GM	24.8				
					24 Months	62	GM	24.1				
					48 Months	7	GM	8.4				
	Previously-Abated Units	16	GM	45.6	6 Months	14	GM	41.1				
					12 Months	14	GM	39.8				
					18 Months	13	GM	37.3				
					24 Months	13	GM	33.0				
	Units Slated for R&M Intervention	58	GM	58.6	Immediately	37	GM	52.5				
					2 Months	37	GM	40.2				
					6 Months	37	GM	36.3				
					12 Months	37	GM	39.9				
					18 Months	37	GM	33.3				
					24 Months	35	GM	35.0				

Table H3-1. (cont.)

Name of Study	Group of Housing Units Within the Study	Pre-Intervention Floor Dust-Lead Loadings			Post-Intervention Floor Dust-Lead Loadings				Difference from Pre-Intervention			
		N	Type of Statistic[1]	Value of Statistic ($\mu g/ft^2$)	Time Following Intervention	N	Type of Statistic[1]	Value of Statistic ($\mu g/ft^2$)	Time Following Intervention	N	Type of Statistic[1]	Value of Statistic ($\mu g/ft^2$)
Baltimore R&M Study[3]	Modern Urban Units	16	GM	10.0	6 Months	15	GM	8.1				
					12 Months	15	GM	7.3				
					18 Months	14	GM	7.8				
					24 Months	14	GM	7.1				
					48 Months	7	GM	8.4				
Baltimore Traditional/ Modified Paint Abatement Study[2]	Traditional	280	GM (95% CI)	549 (482, 645)	Immediately	271	GM (95% CI)	4033 (3269, 4936)				
					6 Months	234	GM (95% CI)	714 (594, 834)				
	Modified	82	GM (95% CI)	642 (433, 908)	Immediately	50	GM (95% CI)	1626 (1082, 2418)				
					6 Months	57	GM (95% CI)	714 (526, 983)				
Boston Interim Dust Intervention Study[2]	Automatic Intervention	10	GM	33	6 Months	10	GM	24				
	Randomized Intervention	9	GM	37	6 Months	9	GM	31				

Table H3-1. (cont.)

Name of Study	Group of Housing Units Within the Study	Pre-Intervention Floor Dust-Lead Loadings			Post-Intervention Floor Dust-Lead Loadings				Difference from Pre-Intervention			
		N	Type of Statistic[1]	Value of Statistic ($\mu g/ft^2$)	Time Following Intervention	N	Type of Statistic[1]	Value of Statistic ($\mu g/ft^2$)	Time Following Intervention	N	Type of Statistic[1]	Value of Statistic ($\mu g/ft^2$)
HUD Grantees	All Grantees	557	Median	19	Immediately Post	557	Median	17	Immediately Post	557	Percent Change	-11%
					6 Months		Median	14	6 Months			-26%
					12 Months		Median	14	12 Months			-26%
	Baltimore	32	Median	41	Immediately Post	32	Median	18				
					6 Months		Median	42				
					12 Months		Median	41				
	Boston	28	Median	24	Immediately Post	28	Median	54				
					6 Months		Median	16				
					12 Months		Median	18				
	Mass.	42	Median	24	Immediately Post	42	Median	20				
					6 Months		Median	11				
					12 Months		Median	9				
	Milwaukee	170	Median	14	Immediately Post	170	Median	15				
					6 Months		Median	10				
					12 Months		Median	10				

Table H3-1. (cont.)

Name of Study	Group of Housing Units Within the Study	Pre-Intervention Floor Dust-Lead Loadings			Post-Intervention Floor Dust-Lead Loadings				Difference from Pre-Intervention			
		N	Type of Statistic[1]	Value of Statistic (μg/ft²)	Time Following Intervention	N	Type of Statistic[1]	Value of Statistic (μg/ft²)	Time Following Intervention	N	Type of Statistic[1]	Value of Statistic (μg/ft²)
HUD Grantees	Minnesota	105	Median	18	Immediately Post	105	Median	18				
					6 Months		Median	18				
					12 Months		Median	18				
	Rhode Island	31	Median	26	Immediately Post	31	Median	7				
					6 Months		Median	6				
					12 Months		Median	6				
	Vermont	43	Median	28	Immediately Post	43	Median	17				
					6 Months		Median	21				
					12 Months		Median	21				
	Wisconsin	48	Median	9	Immediately Post	48	Median	8				
					6 Months		Median	6				
					12 Months		Median	5				
CAP study[4]	Unabated homes				2 years	51	GM (25th %ile) (75th %ile)	15 (4.1) (47)				
	Abated homes				2 years	187	GM 25th %ile 75th %ile	21 (4.9) (76)				
Jersey City (NJ) CLEARS	Intervention Group	42	GM	22	12 Months	40	GM	15				

Table H3-1. (cont.)

Name of Study	Group of Housing Units Within the Study	Pre-Intervention Floor Dust-Lead Loadings			Post-Intervention Floor Dust-Lead Loadings				Difference from Pre-Intervention			
		N	Type of Statistic[1]	Value of Statistic ($\mu g/ft^2$)	Time Following Intervention	N	Type of Statistic[1]	Value of Statistic ($\mu g/ft^2$)	Time Following Intervention	N	Type of Statistic[1]	Value of Statistic ($\mu g/ft^2$)
Paris Paint Abatement Study	Intervention Group	24	Median	83.6					During Intervention	24	Median	+697
									1-2 Months	24	Median	-33.9
									3-6 Months	24	Median	-45.5
Rochester Educational Intervention Study	Intervention Group - Uncarpeted Floors								7 Months	80	Median Absolute Change (IQ Range)	-9.9 (-20,-2.3)
	Intervention Group - Carpeted Floors								7 Months	80		-6.9 (-10,-2.5)

[1] GM = geometric mean. AM = arithmetic mean. CI = Confidence Interval.
[2] Results (for geometric means and medians ONLY) are adjusted to reflect total dust-lead loadings by exponentiating the "bioavailable" dust-lead loadings as reported in the study to the 1.1416 power.
[3] Results for the Baltimore R&M Study are converted from BRM dust-lead loadings to wipe-equivalent loadings.
[4] Results for the CAP study are converted from CAPS cyclone dust-lead loadings to wipe-equivalent loadings.

Table H3-2. Summary of Window Sill Dust-Lead Loadings, Under Wipe Dust Sampling Techniques, at Pre- and Post-Intervention

Name of Study	Group of Housing Units Within the Study	Pre-Intervention Sill Dust-Lead Results			Post-Intervention Sill Dust-Lead Results				Difference from Pre-Intervention			
		N	Type of Statistic[1]	Value of Statistic (µg/ft²)	Time Following Intervention	N	Type of Statistic[1]	Value of Statistic (µg/ft²)	Time Following Intervention	N	Type of Statistic[1]	Value of Statistic (µg/ft²)
Baltimore Experimental Paint Abatement Studies[2]	Study 1 (6 homes)	34	GM (95% CI)	15215 (9389, 24618)	Immediately Post	35	GM (95% CI)	737 (411, 1364)				
					6-9 Months	31	GM (95% CI)	958 (526, 1681)				
	Study 2 (13 homes)	53	GM (95% CI)	2784 (1322, 5891)	Immediately Post	54	GM (95% CI)	19 (9.8, 35)				
					1.5 - 3.5 Years	59	GM (95% CI)	199 (119, 331)				
Baltimore Follow-up Paint Abatement Study[2]	6-Month Follow-up				Immediately Following Clearance	27	GM (95% CI)	50 (32, 81)				
					5-7 Months	27	GM (95% CI)	71 (43, 119)				
	12-Month Follow-up				Immediately Following Clearance	26	GM (95% CI)	50 (31, 81)				
					10-14 Months	26	GM (95% CI)	41 (49, 132)				

Table H3-2. (cont.)

Name of Study	Group of Housing Units Within the Study	Pre-Intervention Sill Dust-Lead Results: N	Pre-Intervention Sill Dust-Lead Results: Type of Statistic[1]	Pre-Intervention Sill Dust-Lead Results: Value of Statistic ($\mu g/ft^2$)	Post-Intervention Sill Dust-Lead Results: Time Following Intervention	Post-Intervention Sill Dust-Lead Results: N	Post-Intervention Sill Dust-Lead Results: Type of Statistic[1]	Post-Intervention Sill Dust-Lead Results: Value of Statistic ($\mu g/ft^2$)	Difference from Pre-Intervention: Time Following Intervention	Difference from Pre-Intervention: N	Difference from Pre-Intervention: Type of Statistic[1]	Difference from Pre-Intervention: Value of Statistic ($\mu g/ft^2$)
Baltimore Follow-up Paint Abatement Study[2]	19-Month Follow-up				Immediately Following Clearance	19	GM (95% CI)	50 (19, 52)				
					14-24 Months	19	GM (95% CI)	147 (66, 324)				
Baltimore R&M Study[3]	All Occupied Units	90	GM	356.2	Immediately	37	GM	185.4				
					2 Months	37	GM	241.4				
					6 Months	66	GM	138.2				
					12 Months	66	GM	136.2				
					18 Months	64	GM	135.1				
					24 Months	62	GM	117.5				
					48 Months	7	GM	37.1				
	Previously-Abated Units	16	GM	163.5	6 Months	14	GM	107.4				
					12 Months	14	GM	116.0				
					18 Months	13	GM	89.1				
					24 Months	13	GM	97.6				
	Units Slated for R&M Intervention	58	GM	778.4	Immediately	37	GM	185.4				
					2 Months	37	GM	241.4				
					6 Months	37	GM	247.0				
					12 Months	37	GM	237.6				
					18 Months	37	GM	246.8				
					24 Months	35	GM	204.9				

Table H3-2. (cont.)

Name of Study	Group of Housing Units Within the Study	Pre-Intervention Sill Dust-Lead Results			Post-Intervention Sill Dust-Lead Results				Difference from Pre-Intervention			
		N	Type of Statistic[1]	Value of Statistic (μg/ft²)	Time Following Intervention	N	Type of Statistic[1]	Value of Statistic (μg/ft²)	Time Following Intervention	N	Type of Statistic[1]	Value of Statistic (μg/ft²)
Baltimore R&M Study[3]	Modern Urban Units	16	GM	45.6	6 Months	15	GM	41.7				
					12 Months	15	GM	40.0				
					18 Months	14	GM	40.5				
					24 Months	14	GM	34.8				
					48 Months	7	GM	37.1				
Baltimore Traditional/ Modified Paint Abatement Study[2]	Traditional	249	GM (95% CI)	3708 (2953, 4600)	Immediately Post	246	GM (95% CI)	11460 (8929, 14654)				
					6 Months	199	GM (95% CI)	4360 (3356, 5674)				
	Modified	45	GM (95% CI)	5209 (3765, 7246)	Immediately Post	64	GM (95% CI)	1496 (1058, 2114)				
					6 Months	66	GM (95% CI)	4662 (3126, 6961)				
Boston Interim Dust Intervention Study[2]	Automatic Intervention	10	GM	787	6 Months	10	GM	210				
	Randomized Intervention	9	GM	205	6 Months	9	GM	110				

Table H3-2. (cont.)

Name of Study	Group of Housing Units Within the Study	Pre-Intervention Sill Dust-Lead Results			Post-Intervention Sill Dust-Lead Results				Difference from Pre-Intervention			
		N	Type of Statistic[1]	Value of Statistic ($\mu g/ft^2$)	Time Following Intervention	N	Type of Statistic[1]	Value of Statistic ($\mu g/ft^2$)	Time Following Intervention	N	Type of Statistic[1]	Value of Statistic ($\mu g/ft^2$)
HUD Grantees	All Grantees	547	Median	258	Immediately Post	547	Median	52	Immediately Post	547	Median Percent Change	-80%
					6 Months		Median	97	6 Months			-62%
					12 Months		Median	90	12 Months			-65%
	Baltimore	32	Median	1191	Immediately Post	32	Median	49				
					6 Months		Median	87				
					12 Months		Median	68				
	Boston	29	Median	174	Immediately Post	29	Median	53				
					6 Months		Median	48				
					12 Months		Median	49				
	Mass.	43	Median	328	Immediately Post	43	Median	32				
					6 Months		Median	77				
					12 Months		Median	50				
	Milwaukee	166	Median	264	Immediately Post	166	Median	84				
					6 Months		Median	231				
					12 Months		Median	217				

Table H3-2. (cont.)

Name of Study	Group of Housing Units Within the Study	Pre-Intervention Sill Dust-Lead Results			Post-Intervention Sill Dust-Lead Results				Difference from Pre-Intervention			
		N	Type of Statistic[1]	Value of Statistic ($\mu g/ft^2$)	Time Following Intervention	N	Type of Statistic[1]	Value of Statistic ($\mu g/ft^2$)	Time Following Intervention	N	Type of Statistic[1]	Value of Statistic ($\mu g/ft^2$)
HUD Grantees	Minnesota	108	Median	266	Immediately Post	108	Median	66				
					6 Months		Median	86				
					12 Months		Median	77				
	Rhode Island	31	Median	314	Immediately Post	31	Median	18				
					6 Months		Median	87				
					12 Months		Median	85				
	Vermont	32	Median	147	Immediately Post	32	Median	21				
					6 Months		Median	60				
					12 Months		Median	40				
	Wisconsin	45	Median	150	Immediately Post	45	Median	22				
					6 Months		Median	37				
					12 Months		Median	51				
CAP study[4]	Unabated homes				2 years	38	GM (25th %ile) (75th %ile)	34 (7.1) (163)				
	Abated homes				2 years	78	GM 25th %ile 75th %ile	66 (11) (339)				
Jersey City (NJ) CLEARS	Intervention Group	39	GM	75	12 Months	36	GM	24				

Table H3-2. (cont.)

Name of Study	Group of Housing Units Within the Study	Pre-Intervention Sill Dust-Lead Results			Post-Intervention Sill Dust-Lead Results				Difference from Pre-Intervention			
		N	Type of Statistic[1]	Value of Statistic ($\mu g/ft^2$)	Time Following Intervention	N	Type of Statistic[1]	Value of Statistic ($\mu g/ft^2$)	Time Following Intervention	N	Type of Statistic[1]	Value of Statistic ($\mu g/ft^2$)
Rochester Educational Intervention Study	Intervention Group								7 Months	80	Median Absolute Change (IQ Range)	-58 (-154,-10)

[1] GM = geometric mean. AM = arithmetic mean. CI = Confidence Interval.
[2] Results (for geometric means and medians ONLY) are adjusted to reflect total dust-lead loadings by exponentiating the "bioavailable" dust-lead loadings as reported in the study to the 1.1416 power.
[3] Results for the Baltimore R&M Study are converted from BRM dust-lead loadings to wipe-equivalent loadings.
[4] Results for the CAP study are converted from CAPS cyclone dust-lead loadings to wipe-equivalent loadings.

APPENDIX I

AN ASSESSMENT OF DUST-LEAD LEVELS IN CARPETED FLOORS AND THEIR RELATION TO CHILDREN'S BLOOD-LEAD CONCENTRATION, USING DATA FROM THE ROCHESTER LEAD-IN-DUST STUDY AND THE HUD GRANTEES PROGRAM EVALUATION

EXECUTIVE SUMMARY TO APPENDIX I

This appendix presents statistical analyses of data from two lead-exposure studies, the Rochester (NY) Lead-in-Dust study and the pre-intervention, evaluation phase of the HUD Lead-Based Paint Hazard Control Grant ("HUD Grantees") Program (data collected through September, 1997), where the analyses addressed the following:

- the need to extend the floor dust-lead loading standard in the §403 rule to include carpeted floors, based on the statistical association between carpet dust-lead loading and blood-lead concentration
- whether a carpet dust-lead loading standard should be different from the §403 uncarpeted floor standard
- whether the standard can be expressed assuming wipe dust collection techniques
- whether the presence of carpets in a house is associated with reducing blood-lead concentration in children within the house (suggesting that carpets may act as a mitigator in reducing the bioavailability potential for lead in floor dust).

While the §403 proposed rule recognized the importance of controlling lead in floor dust when addressing household lead exposures in target housing, it did not suggest a standard to which carpet dust-lead levels would be compared. Wall-to-wall carpeting is likely to be encountered in over three-quarters of target homes in which such a risk assessment is to be done.

Many factors in a child's environment can contribute to the child's blood-lead concentration, and as a result, it is difficult to isolate the effects of specific factors (such as lead in carpet dust) with any degree of accuracy. However, in the analyses within this appendix, increased blood-lead concentrations were statistically significantly associated with increased household average floor dust-lead loadings, regardless of whether the floors were carpeted or uncarpeted. The blood-lead concentration/carpet dust-lead loading relationship did not appear to differ statistically between housing units having mostly carpeted floors and units with mostly uncarpeted floors, and it remains significant after accounting for the effects of certain demographic parameters. While mixed results were observed in analyses that investigated whether the significance of this relationship remained after taking into account the effects of lead in other media for which standards were included in the §403 proposed rule (e.g., soil-lead and window sill dust-lead), there appears to be a sufficient amount of evidence that carpet-dust sampling should not be ignored in a risk assessment, thereby warranting the need for a carpet dust-lead loading standard.

There is evidence in the results presented in this appendix (i.e., when considering various performance criteria) to suggest that if a carpet (wipe) dust-lead loading standard is added to the currently-proposed §403 standards, this standard should be set lower than the standard of 50 $\mu g/ft^2$ for uncarpeted floors. This evidence includes the following:

- While the blood-lead concentration/dust-lead loading relationship is consistent between carpeted and uncarpeted floors, a housing unit's average carpet dust-lead loading tends to be approximately 75% of its average dust-lead loading for uncarpeted floors, assuming wipe collection techniques.

Adding a carpet dust-lead loading standard of 50 $\mu g/ft^2$ does not appear to improve the values of the performance characteristics (e.g., sensitivity, positive predictive value, negative predictive value) to any degree, regardless of whether or not dust from uncarpeted floors is being evaluated for lead content at the same time as carpet dust.

- When adding a carpeted floor dust-lead loading standard, the sum of the four performance characteristics was maximized at a standard of approximately 17 $\mu g/ft^2$ in the analysis based on Rochester study data and from 5 to 13 $\mu g/ft^2$ in the analysis based on HUD Grantees evaluation data, regardless of whether or not dust from uncarpeted floors is being evaluated for lead content at the same time as carpet dust.

When using the Rochester study data to evaluate the performance of a carpet dust-lead loading standard relative to the performance of an uncarpeted floor standard, without regard to standards for any other media, these analyses concluded that in order to achieve the same level of sensitivity observed at an uncarpeted floor dust-lead loading standard of 50 $\mu g/ft^2$, a carpet dust-lead loading standard would need to be no higher than approximately 30 $\mu g/ft^2$. However, other types of performance criteria did not necessarily set a higher carpet standard in such a bad light. For example, negative predictive value was similar across the range of candidate standards (including 50 $\mu g/ft^2$) regardless of whether the standard represented carpeted or uncarpeted floors. The outcome of a regression model-based analysis suggested that a carpet dust-lead loading standard in the range of 50 $\mu g/ft^2$ would be at least as protective as an uncarpeted floor standard at this level, based on the predicted value of blood-lead concentration at which 95% of children exposed at the standard level would be expected to be below.

Experts participating in the §403 Dialogue Group meetings indicated that widespread use of vacuum dust collection methods in risk assessments would not be practical. Furthermore, the dust standards in the §403 proposed rule assumed that wipe collection methods were being used. Therefore, a carpet dust-lead loading standard that was not expressed under wipe collection methods would be very difficult to incorporate by risk assessors. Based on the findings of this appendix, no technical reasons were found to suggest that wipe techniques should be excluded as a candidate dust collection method for carpets.

Whether considering average dust-lead loadings in a housing unit or loadings for individual samples, data in the Rochester study suggest that statistically significant (at the 0.05 level) differences were observed between carpeted-floor-dust samples of different dust collection methods, especially the BRM vacuum sampler versus the others. This finding provides evidence of quantitative differences among the dust collection methods on the amount of lead and dust that is collected from carpeted floors. This implies that floor dust-lead loading standards that may be applicable to carpets should be tailored to the dust collection method being used.

In conclusion, a carpeted floor dust-lead standard is most likely needed, not only from a practicality standpoint, but from a technical one as well. The standard should be based on dust-lead loadings as measured by the wipe sampling method as wipe sampling is more easily employed in the field and is even recommended in the HUD Guidelines (USHUD, 1995). There is some technical evidence that the standard should be lower than the proposed uncarpeted floor standard of 50 $\mu g/ft^2$, possibly as low as 17 $\mu g/ft^2$ or 5 $\mu g/ft^2$, based on analysis of data from the Rochester study and the HUD Grantees program evaluation, respectively. However, a recommended standard depends on the specific performance criteria that are of interest, and the outcomes of characterizing the performance criteria may be associated with considerable data variability.

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I1.0 INTRODUCTION

I1.1 BACKGROUND

The U.S. Environmental Protection Agency (EPA) is conducting scientific research in response to §403 of the Toxic Substances Control Act (TSCA) (Title IV: Lead Exposure Reduction), as amended within Title X of the Housing and Community Development Act, also known as the Residential Lead-Based Paint Hazard Reduction Act of 1992. Through §403, EPA is directed to "promulgate regulations which shall identify ... lead-based paint hazards, lead-contaminated dust, and lead-contaminated soil." On June 3, 1998, EPA proposed regulation to establish standards for lead hazards in most pre-1978 housing and child-occupied facilities (40 CFR Part 745, "Lead; Identification of Dangerous Levels of Lead; Proposed Rule"). The standards imposed in this regulation addressed average dust-lead loading (lead amount per unit area sampled) on uncarpeted floors, average dust-lead loading on window sills, yardwide average soil-lead concentration, and amount (in square feet) of deteriorated lead-based paint. These standards, a focal point of the Federal lead program, identify the presence of lead hazards, defined within TSCA Section 401 as the condition of lead-based paint and the levels of lead-contaminated dust and soil that "would result" in adverse human health conditions.

The §403 proposed hazard standards did not include a standard for dust-lead levels on carpeted floors. At the time, EPA did not have sufficient information on the statistical relationship between dust-lead from carpets and children's blood-lead concentrations to allow a standard to be proposed. However, some researchers have suggested that separate standards for floor dust-lead loadings on carpeted and uncarpeted floor are likely necessary (e.g., Clark, et al., 1996). Also, because the §403 proposed rule specifically stated that the floor dust-lead standard is for uncarpeted floors, additional guidance must be established for risk assessors who encounter only carpeted floors when collecting dust samples in a home for lead analysis. Such an encounter is highly likely based on EPA's analysis of publicly-available data collected from the Lead Paint Supplement of the 1997 American Housing Survey. Based on this analysis, approximately 54 million housing units built prior to 1978 (or 78% of these units) contain some wall-to-wall carpeting. Of these units, wall-to-wall carpeting is found in a living room in approximately 47 million units and in a bedroom in approximately 46 million units (i.e., rooms in which children reside and play most frequently, and therefore, would be targeted in a risk assessment).

This appendix seeks to address the need for a distinct carpeted floor dust-lead standard by investigating how dust-lead levels on carpeted floors impact young children's blood-lead concentration, over and above that captured by the planned standard for uncarpeted floors. In addition, this appendix provides some guidance on whether the standard for uncarpeted floors can be extended to carpeted surfaces, or whether some other standard is more appropriate. While the scientific literature has attempted to address some of these issues (see USEPA, 1997a)[1], this

[1] This appendix has its own reference list at the end of the appendix.

appendix presents the results of statistical analyses on existing data that more clearly and completely address key issues for §403 rule development.

This appendix also presents how the results of dust-lead analyses can differ when a wipe dust collection method (i.e., the method assumed for the dust standards within the §403 rule) is used to sample dust from carpets versus other techniques (e.g., vacuum). As wipe sampling tends to perform differently for different substrates, its performance on carpeted surfaces can vary according to the type of carpet and is likely to be different from uncarpeted surfaces. This issue must also be addressed when considering an appropriate carpet dust-lead standard.

I1.2 OBJECTIVES

The specific objectives of the statistical analyses presented in this appendix are as follows:

1. Assess the need for a carpeted floor dust-lead loading standard by doing the following:

   - Characterize the relationship between floor dust-lead levels and blood-lead concentration in young children and how this relationship differs for carpeted and uncarpeted floors (with and without adjusting for the effects of key demographic variables and for lead levels in other media represented by standards in the §403 proposed rule).

   - Determine the added value of including a carpet standard given the current proposed §403 standards for soil, window sills and uncarpeted floors.

2. Identify appropriate candidates for carpeted floor dust-lead standards and, in particular, whether 50 $\mu g/ft^2$ (i.e., the proposed uncarpeted floor dust-lead standard from the §403 proposed rule) should be considered as one candidate.

3. Determine whether the wipe technique is acceptable for sampling dust from carpeted floors for evaluating the risk of lead exposure associated with carpet-dust, or whether alternative vacuum methods are more appropriate.

The appendix addresses these objectives by presenting the results of statistical analyses on existing data from two lead-exposure studies: the Rochester (NY) Lead-in-Dust study, and the pre-intervention, evaluation phase of the HUD Lead-Based Paint Hazard Control Grant ("HUD Grantees") Program (data collected through September, 1997).

The conclusions made as a result of the analyses conducted in support of the above objectives were presented in Section 6.5 of the §403 risk analysis supplement report. For the two studies whose data are analyzed in this appendix, Section I3 presents relevant information on study design and data handling that should be considered when interpreting the results and conclusions of these analyses. The statistical methods used in these analyses are presented in Section I4, and detailed results of these analyses are presented in Section I5. Each subsection within Sections I4 and I5 is devoted to addressing one of the above three objectives.

I2.0 THE POTENTIAL FOR LEAD EXPOSURE ASSOCIATED WITH CARPET DUST

Several field and laboratory studies documented in the scientific literature have investigated the nature and magnitude of lead in carpet-dust, as well as how to characterize dust-lead contamination in carpets. For example, Adgate et al., 1995, corroborate evidence that carpets can hold large amounts of dust and soil, thereby increasing the likelihood of carpets being lead-contaminated relative to other surfaces. In older, chronically-contaminated carpets, exposure to lead within the carpet can be delayed over time as normal cleaning procedures and activities can gradually bring deeply-embedded lead-dust to the carpet surface (Adgate et al., 1995). As a result, such carpets can represent a continuing source of lead exposure, even after other interventions have reduced or eliminated other exposure sources.

While the performance of wipe techniques to collect carpet-dust can vary across different types of carpet, Wang et al., 1995, found that the dust collection efficiency of vacuum techniques on carpeting can also vary based on factors such as carpet pile height, vacuum velocity, dust loading within the carpet, and relative humidity[2].

A detailed presentation of the key findings of published studies investigating the measurement of lead levels in carpet, the relationship of these levels with blood-lead concentration in children, and efforts to mitigate lead exposures associated with carpets, is found in USEPA, 1997a.

I3.0 STUDY INFORMATION

To address the above objectives (Section I1.2), statistical analyses were performed on data from the Rochester Lead-in-Dust study and on pre-intervention data from the HUD Grantees program evaluation. These studies measured lead levels in environmental media such as exterior soil and interior dust collected from carpeted and/or uncarpeted floors, window sills, and window wells. Also measured were blood-lead concentrations in resident children. The final report on the Rochester study is found in The Rochester School of Medicine and NCLSH, 1995. Rochester study results addressing specific questions are found in Lanphear et al., 1995; Lanphear et al., 1996a; Lanphear et al., 1996b; and Emond et al., 1997. NCLSH and UCDEH, 1998, presents an interim report of data collected in the HUD Grantees program evaluation through September, 1997.

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[2] Both Adgate et al., 1995, and Wang et al., 1995, document findings from various phases of EPA's Childhood Lead Exposure Assessment and Reduction Study.

Section I3.1 presents an overview of the designs of these studies, including the dust collection methods used and types of data collected, and discusses the relevance of using data from these studies in addressing the objectives of this appendix. The data used to address these objectives and the data endpoints used in the analyses presented in this appendix are found in Section I3.2.

I3.1 STUDY OVERVIEWS

I3.1.1 The Rochester Lead-in-Dust Study

Performed in 1993, the Rochester Lead-in-Dust study was a cross-sectional lead-exposure study of 205 children aged 12-31 months who lived in the city of Rochester, New York, and had no known history of elevated blood-lead concentrations. The objectives of this study were to evaluate 1) the effect of dust-lead contamination on the blood-lead concentrations of these children, 2) how this effect differed under differing dust collection methods, 3) whether dust-lead loadings or concentrations were more predictive of children's blood-lead concentrations, and 4) which surfaces should be routinely sampled for dust in a risk assessment.

The study sample consisted of a random sample of children born at three urban hospitals, where the births were listed within hospital birth registries and occurred from March 1, 1991, through September 30, 1992. Thus, the sample was considered representative of the general birth population of the city of Rochester during this period. However, as the study was conducted in a single urbanized area, the sample may not be representative of the entire nation.

The children in the study sample primarily had moderate exposure to lead at their residence. The geometric mean blood-lead concentration for these children was 6.37 µg/dL, compared to 3.1 µg/dL for U.S. children aged 1-2 years as estimated by Phase 2 of the Third National Health and Nutrition Examination Survey (NHANES III), which was performed from 1991-1994 (CDC, 1997). Approximately 23% of the children in the study had blood-lead concentrations of at least 10 µg/dL, and 3% had blood-lead concentrations of at least 20 µg/dL. This compares to national percentages of children aged 1-2 years (as estimated by Phase 2 of NHANES III) of 6% at or above 10 µg/dL and 0.43% at or above 20 µg/dL (CDC, 1997; USEPA, 1997b). Children in this study tended to reside in older housing (84% of the units were denoted as being built prior to 1940) and to belong to households in the lower-income bracket, both characteristics of residential environments with a high potential for lead-based paint hazards. White children and African-American children participated in the study at approximately equal proportions, each constituting approximately 42% of the monitored children in the study.

Three dust sampling methods were used to collect dust samples in the Rochester study: the BRM vacuum sampler, the DVM vacuum sampler, and the wipe method. The BRM vacuum sampler is a modified, portable version of the high-volume small surface sampler (HVS3; Roberts et al., 1991), an ASTM standard device for collecting dust "from carpets or bare floors to be analyzed for lead, pesticides, or other chemical compounds and elements" (ASTM, 1996).

The DVM vacuum sampler was developed for use in studies that characterize lead exposure pathways from environmental media to blood (Que Hee et al., 1985). In sampling carpet-dust, the DVM vacuum tends to collect only the surface dust that is more readily available to children (generally particles less than 250 µm in diameter), and not the more deeply-embedded dust in the carpet that the BRM vacuum is capable of sampling. The third method, wipe sampling, collects dust from a surface by wiping the surface with a premoistened digestible wipe. ("Little Ones" brand baby wipes were used in the Rochester study.) As it can be difficult for the wipe method to collect dust embedded deeply within carpet fibers, it tends to collect only the most readily available surface dust from carpets.

From August to November, 1993, floor-dust samples in the Rochester study were collected from five rooms within a housing unit: the entryway, child's bedroom, child's principal play area, kitchen, and living room. Window sill dust samples were collected within four rooms: the child's bedroom, child's principal play area, kitchen, and living room. Window well dust samples were collected within three rooms: the child's bedroom, child's principal play area, and kitchen. Within each room, three dust samples were collected side-by-side on a given component type, with the first sample collected using a wipe, the second using the DVM vacuum, and the third using the BRM vacuum. For floor-dust samples, information was also collected on whether or not the floor was carpeted, and if so, the condition of the carpet (good, average, or poor) and whether the carpet was of high-pile or low-pile.

Among the data collected in the Rochester study were the following:

- lead loading (amount of lead per sample area) in dust samples from floors, window sills, and window wells, using each of the three dust collection methods. Dust samples were analyzed using flame atomic absorption (FAA) or graphite furnace atomic absorption spectrophotometry (GFAAS).

- lead concentration (amount of lead per weight of sample) in dust samples from floors, window sills, and window wells, using the DVM and BRM vacuum methods.

- lead concentration in soil samples collected from the dripline (foundation) at 186 housing units and from children's play areas at 87 units. Soil samples were fractionated into fine and coarse soil fractions, both of which were analyzed using FAA. The fine soil fraction results were considered in the analyses of this appendix.

- blood-lead concentration for participating children, with their blood collected via venipuncture and analyzed by GFAAS.

- lead levels on up to 15 painted surfaces in the unit from within the kitchen, child's bedroom, child's principal play area, and entryway, as well as on the exterior. The Microlead I portable x-ray fluorescence (XRF) measurement device was used, but laboratory testing of paint chips was also employed if the XRF could not be used or if the result was deemed inconclusive. A rating on the extent of any deterioration of the sampled paint (0-5% deteriorated, 5-15% deteriorated, >15% deteriorated) was also determined.

- demographic information on the household and on the resident children, such as income level, age of child, nutritional and feeding information, types of activities, and tendency for pica.

The study units generally had low dust-lead loadings on floor surfaces in this study. The study-wide geometric mean dust-lead loading for wipe dust samples were 16 $\mu g/ft^2$ for uncarpeted floors and 11 $\mu g/ft^2$ for carpeted floors.

I3.1.2 The HUD Grantees Program Evaluation

In 1993, 70 state and local government agencies were awarded grants by the U.S. Department of Housing and Urban Development (HUD) to "initiate or expand lead-based paint inspection, abatement, and training certification programs in order to reduce the health hazards associated with exposure to lead-based paint and lead dust ... and to plan and implement cost-effective testing, abatement, and financing programs, including the testing of innovations that can serve as models for other jurisdictions interested in addressing this problem ..." (HUD, 1992 Notice of Funding Availability). This ongoing national program is known as the HUD Lead-Based Paint Hazard Control Grant Program in Private Housing, or the HUD Grantees program evaluation. In this program, enrollment and lead hazard control interventions are still ongoing, with post-intervention environmental monitoring continuing for up to three years following interventions.

The grantees in the HUD Grantees program evaluation are implementing effective, low-cost intervention and financing programs to control lead-based paint hazards in privately-owned low- and middle-income housing. As part of a formal evaluation of the program, the fourteen grantees listed in Table 3-4 of the §403 risk analysis report are also collecting extensive data on environmental, biological, demographic, housing, cost, and hazard-control aspects of the intervention activities that they are conducting in this program. This evaluation is intended to determine the relative cost and effectiveness of the various methods used by states and local governments to reduce lead-based paint hazards in housing. Among the pre-intervention data being collected in this evaluation are the following:

- lead loadings in dust samples using wipe collection techniques (the DVM vacuum sampler was occasionally used on carpets). Carpeted and uncarpeted floors, window sills, and window wells were sampled. Sampled rooms included entryways, children's principal play room (or living room), kitchen, and up to two children's bedrooms. The program directed that two dust samples per surface type per room should be taken.

- blood-lead concentration for children between the ages of six months and six years (although data exist for children as old as eight years). While the program recommended venipuncture collection techniques, some grantees used fingerstick methods occasionally. Blood samples were analyzed by GFAAS or by anodic stripping voltammetry (ASV).

- soil-lead concentration in composite soil samples collected from the dripline (foundation) and from children's play areas. Soil sampling was optional in this program, collected by only 8 of the 14 grantees.

- lead levels on painted surfaces measured to determine the presence of lead-based paint. Portable XRF measurement techniques were used, but laboratory testing of paint chips was also employed if XRF measurements were indeterminate.

- demographic information on the household and on the resident children, such as income level, age of house, age of child, and mouthing behavior.

Grantees collecting environmental and blood samples followed specified sampling protocols and used standard data collection forms developed specifically for this evaluation.

The pre-intervention data considered in this analysis were collected from February, 1994, to August, 1997, and therefore provide some of the most recent information on baseline environmental-lead measurements and their relationship with blood-lead concentration in children. However, the HUD Grantees data are not meant to be representative of data for the nation as a whole. The grantees were not selected to achieve a statistical-based sample of geographic areas of the country. In addition, as it was HUD's desire to emphasize local control of the individual programs, each grantee participating in the program was given some freedom in developing their approach to recruitment and enrollment. Some grantees targeted high-risk neighborhoods in their enrollment procedure, while others enrolled only homes with a lead-poisoned child, while still others considered unsolicited applications. Thus, when interpreting results of any analyses of data from this program, one should be aware that these data represent housing units that are more likely to contain lead-based paint hazards or to contain children with elevated blood-lead concentrations than is the population as a whole (e.g., higher incidence of older or low-income housing or sampling from neighborhoods with a history of lead-based paint hazards).

I3.2 DATA HANDLING

For the analyses presented in this appendix, Rochester study data were obtained in electronic format directly from the Rochester study team. Pre-intervention data collected in the HUD Grantees program evaluation through September, 1997, were obtained from the University of Cincinnati. Outlier screens and logic checks were performed on the HUD Grantees data prior to analysis, and unusual data values were checked for accuracy and corrected if necessary.

Version 6.12 of the SAS® System was used to manage the data and conduct all data summaries and statistical analyses presented in this appendix.

Data for all 205 housing units in the Rochester study and for 395 housing units across 13 of the 14 HUD grantees were included in the analyses presented in this appendix. As the effects of carpeting on the relationship between lead-based paint hazard and children's blood-lead concentration were to be investigated in this appendix, analyses of HUD Grantees data involved only those housing units which had data on both of the following:

- blood-lead concentration for at least one resident child, where the blood samples were obtained by venipuncture, and
- floor dust-lead loadings, where the type of floor surface (carpeted, uncarpeted) and the dust collection method (wipe or DVM) were specified.

In addition, to ensure the integrity of the relationship between environmental-lead and blood-lead measurements in a given unit, the following blood-lead concentration data were omitted from the analysis of HUD Grantees data:

- data for children who had earlier treatment for lead poisoning, such as chelation
- data for children residing in the unit for less than three months
- data for children not residing in the unit until after dust samples were collected
- data for children whose blood was sampled more than four months after dust sample collection.

Data for all Rochester study units were considered in the analyses in this appendix, as the Rochester study design allowed for more detailed analyses on relationships between dust-lead measurements for different dust collection methods.

The analyses presented in this appendix assumed that each housing unit in both studies was associated with a blood-lead concentration for a single child. This was true for units in the Rochester study, but some units in the HUD Grantees program evaluation had blood-lead concentrations for multiple children. For these units, data for only the youngest child 12 months and older were considered. If all children in a unit were younger than 12 months, data for the oldest child was selected. In one instance, when these criteria did not yield a single child (e.g., twins born on the same day), a child was selected randomly from those meeting the criteria.

When reviewing the data more closely (Appendix I2), some of the HUD grantees frequently reported the same dust-lead loading value across different locations or housing units. Although not confirmed, this value is likely an estimated lead level that is below a limit of detection and is equal to the detection limit divided by the square root of two. In the analyses presented in this appendix, these values were treated as actual values rather than censored values. However, excessive numbers of data points that represent not-detected lead levels can impact underlying data assumptions relevant to the statistical analyses and can introduce considerable bias to the analysis results.

In each study, the floor dust-lead measurements for each housing unit were categorized by dust collection method, measurement type (loadings or concentrations), and whether the sample was taken from a carpeted or an uncarpeted surface. These categories are presented in Table I3-1. Floor dust-lead measurements could be placed into ten categories in the Rochester study and three categories in the HUD Grantees program evaluation. For each housing unit, the area-weighted arithmetic average of floor dust-lead loadings (i.e., each measurement is weighted by the area of the sample) was calculated for each dust collection method used and floor surface type sampled in the unit. In addition, within the Rochester study, the mass-weighted arithmetic average of floor dust-lead concentrations (i.e., each measurement is weighted by the mass of the sample) was calculated for each vacuum dust collection method used and floor surface type sampled in the unit. While floor dust-lead loading as measured by the wipe method was the primary floor-dust endpoint used in the statistical analyses, descriptive statistics were reported in Appendix I2 for all three sampling methods and both measurement types (loading and concentration). Typically, all available interior floor-dust measurements in the unit, including measurements from rooms other than those specified within the study design, were used in calculating these endpoints. However, in the Rochester study, data for dust samples from exterior surfaces such as driveways and porches were not included.

Table I3-2 contains additional endpoints used in the statistical analyses that were calculated from data in these two studies. As indicated in this table, dust-lead measurements on window components were summarized within each unit by taking area-weighted averages (for loadings) or mass-weighted averages (for concentrations) by dust collection method. Only dust-lead data for windows located in a kitchen, play area, living room, or bedroom were considered in the Rochester study. When calculating the endpoint representing paint-lead level, lead measurements corresponding to intact paint were set to zero (as intact paint was not considered to pose a lead hazard), and the 75th percentile of all paint-lead measurements in the unit (i.e., the level where 75% of the measurements were below it) was determined. The "lead-based paint hazard score" is a measure of both the extent of deteriorated lead-based paint in either the interior or the exterior of the unit and paint pica tendencies in the resident child. The endpoints in Table I3-2 were among those considered as predictors of blood-lead concentration in developing the empirical model used in the §403 risk analysis (USEPA, 1997b).

Table I3-1. Types of Floor Dust-Lead Samples and Measurements Taken in the Two Studies

Measurement	Sample Type	Data Collected in the Rochester Study?	Data Collected in the HUD Grantees Evaluation?
Dust-lead loading	Wipe dust collection on carpeted floors	Yes	Yes
	BRM (vacuum) dust collection on carpeted floors	Yes	No
	DVM (vacuum) dust collection on carpeted floors	Yes	Yes
	Wipe dust collection on uncarpeted floors	Yes	Yes
	BRM (vacuum) dust collection on uncarpeted floors	Yes	No
	DVM (vacuum) dust collection on uncarpeted floors	Yes	No
Dust-lead concentration	BRM (vacuum) dust collection on carpeted floors	Yes	No
	DVM (vacuum) dust collection on carpeted floors	Yes	No
	BRM (vacuum) dust collection on uncarpeted floors	Yes	No
	DVM (vacuum) dust collection on uncarpeted floors	Yes	No

Table I3-2. Definitions of Additional Endpoints Included in Data Summaries and/or Used in Statistical Analyses Within This Appendix

<table>
<tr><th rowspan="2">Endpoint</th><th colspan="2">Definition of Endpoint</th></tr>
<tr><th>Based on Rochester Study Data</th><th>Based on HUD Grantees Program Evaluation Data</th></tr>
<tr><td rowspan="2">Percentage of floor area consisting of carpeted surfaces</td><td>Percentage of total sampled floor area consisting of carpeted surfaces (determined across all dust collection methods as well as for each method)</td><td rowspan="2">Percentage of total sampled floor area consisting of carpeted surfaces (determined across all dust collection methods as well as for each method)</td></tr>
<tr><td>Percentage of total sampled carpeted floor area corresponding to high-pile versus low-pile carpet (calculated only for units with carpet dust sample data)</td></tr>
<tr><td rowspan="2">Lead levels on window sills</td><td>Area-weighted arithmetic average of dust-lead loadings on window sills (determined separately for wipe, DVM, BRM)</td><td rowspan="2">Area-weighted arithmetic average of wipe dust-lead loadings on window sills</td></tr>
<tr><td>Mass-weighted arithmetic average of dust-lead concentrations on window sills (determined separately for DVM, BRM)</td></tr>
</table>

Table I3-2. (cont.)

Endpoint	Definition of Endpoint	
	Based on Rochester Study Data	Based on HUD Grantees Program Evaluation Data
Lead levels on window wells	Area-weighted arithmetic average of dust-lead loadings on window wells (determined separately for wipe, DVM, BRM) Mass-weighted arithmetic average of dust-lead concentrations on window wells (determined separately for DVM, BRM)	Area-weighted arithmetic average of wipe dust-lead loadings on window wells
Lead levels in soil	Average soil-lead concentration (fine soil fraction only) across dripline and play areas, or for only one area if no data exist for the other area	Defined in the same manner as for the Rochester study data, but no separation of sample into size fractions was done
Lead levels in interior paint[1]	75th percentile of interior XRF paint-lead measurements in the unit, with the XRF measurement for a given surface reset to zero when the measurement exceeded 1.0 mg/cm^2 but the paint on the surface was considered intact, or when the measurement was below 1.0 mg/cm^2	Defined in the same manner as for the Rochester study data.
Lead levels in exterior paint[1]	75th percentile of exterior XRF paint-lead measurements in the unit, with the XRF measurement for a given surface reset to zero when the measurement exceeded 1.0 mg/cm^2 but the paint on the surface was considered intact, or when the measurement was below 1.0 mg/cm^2	Defined in the same manner as for the Rochester study data.
Lead-based paint hazard score (i.e., extent of a lead-based paint hazard)[2]	=0 if no deteriorated lead-based paint exists in the unit, or the child exhibits no paint pica =1 if deteriorated lead-based paint is present in the unit, and the child exhibits paint pica rarely =2 if deteriorated lead-based paint is present in the unit, and the child exhibits paint pica at least sometimes	=0 if no deteriorated lead-based paint exists in the unit, or the child puts fingers or other objects in his/her mouth less than once/week or not at all =1 if deteriorated lead-based paint is present in the unit, and the child puts fingers or other objects in his/her mouth several times/week =2 if deteriorated lead-based paint is present in the unit, and the child puts fingers or other objects in his/her mouth several times/day or more.
Other demographic endpoints [3]	Ownership status (owner- vs. renter-occupied), household annual income, age of child, parents' education, cleaning frequency, mouthing behavior, family history of lead, race, gender.	Ownership status (owner- vs. renter-occupied), household annual income, age of house, age of child, mouthing behavior, race, season of measurement, gender, grantee.

[1] The 75th percentile is that value for which 75% of the observed XRF measurements in a housing unit are lower (XRF measurements exceeding 1.0 mg/cm^2 for surfaces covered with intact paint were reset to 0 prior to determining the 75th percentile).

[2] A household's lead-based paint hazard score incorporates information on the presence of deteriorated lead-based paint in the unit and paint pica behavior in the child whose blood is tested for lead levels. The score was determined separately for the interior and exterior of the unit.

[3] See Table I4-1 for more details on these endpoints.

The databases for both studies included a variable identified as the year in which the housing unit was built. This variable, which is either a specified year (Rochester study) or a category representing a range of years (HUD Grantees), has historically been an important indicator of the presence and magnitude of lead-based paint hazard. (Lead in residential paint was only gradually phased out before its ban in 1978, plus paint films deteriorate over time.) However, the year specified in the Rochester study data may be unreliable, as the Rochester study team has indicated that it was taken from public tax assessor records. It is possible that the tax assessment records of some units actually contain a later year in which a certain event, such as extensive remodeling, was performed that can affect tax assessments. Therefore, information on age of unit was not used in the analysis of Rochester study data.

I4.0 METHODS

This section presents the statistical methods that were developed to address the objectives in Section I1.2. The results of applying these methods to data from the Rochester study and/or the HUD Grantees evaluation are detailed in Section I5 of this appendix.

I4.1 ASSESSING THE NEED FOR A CARPETED FLOOR DUST-LEAD LOADING STANDARD

In the §403 proposed rule, EPA proposed a standard of 50 $\mu g/ft^2$ for uncarpeted floor dust-lead loading measured using the wipe method (Section I1.1). However, risk assessors may encounter situations where nearly all of the floor in a unit is covered by carpeting, or the only uncarpeted floor is in an area where lead exposure to children may be minimal (e.g., bathroom). Clearly, in these situations, any floor-dust samples would come from carpeted floors. Therefore, a standard would be needed against which to compare these carpeted floor dust-lead measurements.

One may argue, however, that if no association is found to exist between carpeted floor dust-lead loading and blood-lead concentration, then sampling dust from carpets during a risk assessment (and, therefore, the need for a carpet dust-lead standard) may not be necessary. Section I4.1.1 presents various methods used to examine whether a statistically significant association exists between carpeted floor dust-lead loading and blood-lead concentration, both adjusting for and not adjusting for relevant demographic variables, and how this association compares with that where the floor dust is assumed to have come from uncarpeted floors.

As documented in Section I1.1, the §403 proposed rule included standards for lead in dust from uncarpeted floors and window sills, as well as for lead in soil and for deteriorated paint. Exceeding any of these standards will trigger the need for certain interventions in a housing unit. Nevertheless, certain housing units containing children with high blood-lead concentrations may not exceed any of these standards, but perhaps would exceed a properly-established standard for lead in carpet dust. To determine the need for a carpet dust-lead loading standard in the context of the §403 proposed standards, Sections I4.1.2 and I4.1.3 portray modeling and non-modeling approaches, respectively, for evaluating the added benefit that a carpet dust-lead standard may bring to the set of proposed standards.

I4.1.1 Investigating the Association Between Dust-Lead Loading and Blood-Lead Concentration for Carpeted and Uncarpeted Floors

This subsection presents methods for examining the relationship between area-weighted arithmetic average floor dust-lead loading and children's blood-lead concentration without considering other environmental-lead sampling. (See Section I4.1.2 for a similar analysis which does control for other environmental-lead sampling.) Correlation coefficients and regression models that account for effects of demographic covariates were used to assess the relationship between blood-lead and dust-lead for both carpeted and uncarpeted floors.

Unless otherwise mentioned, the following approaches were taken within each method described in this subsection:

- The analyses were applied separately to carpeted and uncarpeted floor dust-lead loading data (assuming wipe dust collection techniques).

- Average household dust-lead loadings and blood-lead concentrations were log-transformed, as typically the underlying distributions of these data parameters tend to follow a normal distribution more closely upon taking a log-transformation.

- When floor dust-lead loadings were assumed to be from carpeted surfaces, the data for each housing unit were weighted by the proportion of total floor wipe sample area in the unit that was carpeted. (This proportion acted as a surrogate for the proportion of actual floor area in the unit that was carpeted.)

- When floor dust-lead loadings were assumed to be from uncarpeted surfaces, the data for each housing unit were weighted by the proportion of total floor wipe sample area in the unit that was uncarpeted. (This proportion acted as a surrogate for the proportion of actual floor area in the unit that was uncarpeted.)

I4.1.1.1. Correlations Between Floor Dust-Lead Loading and Blood-Lead Concentration. Pearson correlation coefficients between log-transformed average dust-lead loading and log-transformed blood-lead concentration were calculated for carpeted floors and uncarpeted floors separately, in order to assess the degree of linear relationship between these variables for both types of floor surfaces. Scatterplots of these data were also generated to further explain the nature of the relationship for both surfaces.

I4.1.1.2. Univariate Regression of Blood-Lead Concentration on Floor Dust-Lead Loading. The log-linear relationship between average floor dust-lead loading and blood-lead concentration was investigated by fitting the following regression model (separately for carpeted and uncarpeted floors):

$$\log(PbB_i) = \mu + \alpha * \log(PbD_i) + \varepsilon_i \quad (1)$$

where PbB_i represents the blood-lead concentration for the child in the i^{th} housing unit, PbD_i is the observed average dust-lead loading (from either carpeted or uncarpeted floors, depending on the model fit) for the i^{th} housing unit, μ and α are parameters representing the intercept and slope of the model, respectively, and ε_i represents error not explained by the model and is presumably characterized by a normal distribution with mean zero and standard deviation σ. When fitting the model to HUD Grantees data, separate intercepts (μ) were estimated for the different grantees but not separate slopes (α), as preliminary analyses had determined that there was no significant improvement to the model by considering grantee-specific slopes. A statistically non-zero slope (α) suggests that the average dust-lead loading is significantly associated with blood-lead concentration by the methods used in the model fitting.

Note that model (1) does not take into account the effects that lead exposure in other media or the effects of certain demographic variables may have on blood-lead concentration. If these effects are highly correlated with the effect of floor dust-lead loading, then a portion of the effect of floor dust-lead loading on blood-lead concentration that is observed from fitting model (1) may actually be the result of these other factors. Therefore, the degree of *association* between the floor dust-lead loading and blood-lead concentration in these regressions is not necessarily the degree to which floor dust-lead loading *causes* a change in blood-lead concentration.

As it was desired to express blood-lead concentration as a function of *observed* dust-lead loading, the model fitting does not adjust for measurement error in the dust-lead loading measurement.

I4.1.1.3. Comparing the Dust-Lead Loading/Blood-Lead Concentration Relationship Between Homes With Mostly Carpeted Floors and Homes With Mostly Uncarpeted Floors. Most housing units in the Rochester study and HUD Grantees evaluation had floor-dust samples taken from both carpeted and uncarpeted floors. Thus, it was difficult for an analysis of these data to isolate the role that carpeting had on the relationship between lead in floor-dust and children's blood-lead levels. One approach taken to investigate the role of carpeting was to consider how this relationship differed between two groups of housing units in each study:

- units where floor-dust was sampled from mostly carpeted floors (i.e., > 50% carpet-dust samples, by area)
- units where floor-dust was sampled from mostly uncarpeted floors (i.e., < 50% carpet-dust samples, by area)

(Units where total sampled floor area consisted of equal proportions of carpeted and uncarpeted floors were omitted from this analysis.) The underlying assumption here was that if the majority of sampled floor area in a housing unit was from a single floor surface type, then a resident child's floor dust-lead exposure derived mostly from that surface type.

For each housing unit, let pc_i equal the proportion of the total floor wipe area sampled in the i^{th} housing unit that was carpeted. Then for each study, the following model was fitted twice, once for each of two definitions for the predictor variable relating average floor dust-lead loading in a household:

$$\log(PbB_i) = \mu + \alpha*\log(PbD_i^*) + \beta_0*SURF_i + \beta_1*SURF_i*\log(PbD_i^*) + \varepsilon_i \qquad (2)$$

where, in each fit, $SURF_i$ equals 0 or 1 depending on whether pc_i is less than or greater than 50%, respectively, and PbB_i represents the blood-lead concentration for the child in the i^{th} housing unit. The two possible definitions of $\log(PbD_i^*)$ were as follows:

<u>Fit #1: Surface Majority</u>. Here, $\log(PbD_i^*)$ equals the log-transformed average dust-lead loading for the floor surface type which makes up the <u>majority</u> of the sampled floor area:

$$\log(PbD_i^*) = \begin{cases} \log(PbD_i \text{ for carpeted surfaces}) \text{ if } pc_i > 0.5 \\ \log(PbD_i \text{ for uncarpeted surfaces}) \text{ if } pc_i < 0.5 \end{cases}$$

In this model fit, the ith housing unit was weighted by pc_i if $pc_i > 0.5$ and by $(1-pc_i)$ if $pc_i < 0.5$.

<u>Fit #2: Weighted Average</u>. Here, $\log(PbD_i^*)$ equaled a weighted average of average carpeted-floor dust-lead loading and average uncarpeted-floor dust-lead loading in a household, with the weights determined by pc_i:

$$\log(PbD_i^*) = pc_i * \log(PbD_i(\text{carpeted})) + (1-pc_i)* \log(PbD_i(\text{uncarpeted}))$$

Equal weight was given to all housing units in this model fit.

Therefore, the first fit only considered dust-lead data for the surface type having the majority of sample area (and each housing unit was weighted by the proportion of total sample area representing this surface type), while the second fit considered an overall household average across both types of floor surfaces.

The parameters of most importance when interpreting these analysis results were the parameters β_0 and β_1. These parameters are "effect modifiers" that represent the change in the intercept (μ) and slope (α), respectively, when homes have greater than 50% of floor-dust sampled from carpeted floors. If both β_0 and β_1 are not significantly different from zero, then these results imply that the statistical relationship between blood-lead concentration and floor dust-lead loading does not differ significantly between homes that are mostly carpeted and homes that are mostly uncarpeted.

As in model (1), when fitting model (2) to HUD Grantees data, separate intercepts (μ) were estimated for the different grantees, but not grantee-specific slopes.

I4.1.1.4. Investigating the Association Between Floor Dust-Lead Loading and Blood-Lead Concentration, Controlling for Demographic Variables. It is possible that even if one concludes from fitting models (1) and (2) that the association between floor dust-lead loading and blood-lead concentration is statistically significant, the significance may actually be due to confounding effects of certain demographic variables such as income, age of house, etc. In this analysis, the demographic variables listed in Table I4-1 were considered as predictor variables in an expanded version of model (1) from Section I4.1.1.1. Certain variables from Table I4-1 were added to the regression model using stepwise selection techniques, and the household's average floor dust-lead loading was added to the model last. This approach, therefore, evaluated the degree of association between floor dust-lead loading and blood-lead concentration after adjusting for the effects of important demographic variables.

The expanded version of model (1) takes the form

$$\log(PbB_i) = \mu + \sum_k \beta_k * Z_{k,i} + \alpha * \log(PbD_i) + \varepsilon_i \qquad (3)$$

where $Z_{k,i}$ denotes the value (for the ith housing unit) of the kth in a series of selected demographic variables, β_k denotes the slope parameter associated with $Z_{k,i}$, and the remaining notation is the same as for model (1) above. Model (3) was fit twice: once using carpeted floor dust-lead loading when determining PbD_i and once using uncarpeted floor dust-lead loading.

When fitting model (3) to the HUD Grantees data, separate intercepts (μ) for the different grantees were included among the pool of demographic variables in Table I4-1 that were considered in the stepwise procedure rather than being forced into the model. Therefore, the stepwise procedure was allowed to choose which grantees had significantly different intercepts from the others.

I4.1.2 Investigating the Association Between Carpeted Floor Dust-Lead Loading and Blood-Lead Concentration, Controlling for Other Environmental-Lead Sampling

The §403 proposed rule set standards for lead in dust from uncarpeted floors and window sills, lead levels in soil, and the amount of deteriorated lead-based paint within a household. To investigate the extent to which a carpeted floor dust-lead loading standard may address that portion of a child's total lead exposure that is not attributable to the environmental-lead levels addressed by the proposed standards, the contribution of carpeted floor dust-lead loading measurements to the prediction of blood-lead concentration, over and above the contributions of the lead measures that were compared to the §403 standards, was evaluated. The data analysis consisted of two parts:

Table I4-1. Demographic Variables Considered in Stepwise Regressions Examining the Association Between Floor Dust-Lead Loading and Blood-Lead Concentration

Study	Demographic Variable	Definition
Rochester	Age	Child age and square of child age (considered jointly)
Rochester	Education	0 = ≤High School, 1 = > High School
Rochester	Cleaning Frequency [1]	(Frequency of Sweeping + Frequency of Vacuuming + Frequency of Cleaning Window Wills + Frequency of Wet Mopping)/16
Rochester	Income	0 = ≤$15,500 per year, 1 = > $15,500 per year
Rochester	Mouthing Behavior [2]	(Mouth on Window Sill + Pacifier + Soil Pica + Sucks Thumb)/16
Rochester	Lead in Family History	0 = No, 1 = Yes
Rochester	Paint Pica Hazard	= 0 if the sum of interior LBP hazard score and exterior LBP hazard score (Table I3-1) equals 0 or 1 = 1 if the sum equals 2, 3, or 4
Rochester	Race	0 = Non-white, 1 = White
Rochester	Sex	0 = Female, 1 = Male
Rochester	Rent/Own	0 = Own, 1 = Rent
HUD Grantee	Age	Child age and the square of child age (considered jointly)
HUD Grantee	Income	0 = ≤$15,500 per year, 1 = > $15,500 per year
HUD Grantee	Mouthing Behavior [3]	(Fingers in Mouth + Toys in Mouth)/6
HUD Grantee	Paint Pica Hazard	= 0 if the sum of interior LBP hazard score and exterior LBP hazard score (Table I3-1) equals 0 or 1 = 1 if the sum equals 2, 3, or 4
HUD Grantee	Race	0 = Non-white, 1 = White
HUD Grantee	Sex	0 = Female, 1 = Male
HUD Grantee	Year Home Built	0 = Pre-1940, 1 = Post-1940
HUD Grantee	Season	0 = Fall/Winter, 1 = Spring/Summer

[1] Each of the four frequency variables in the sum has possible values 0 = Never, 1 = Less than once per month, 2 = Monthly, 3 = Bimonthly, 4 = More than once per week. Thus, the sum ranges from 0 to 1 and was not calculated if data for any of the terms in the sum were not available.

[2] Each of the four mouthing variables in the sum has possible values 0 = Never, 1 = Rarely, 2 = Sometimes, 3 = Often, 4 = Always. Thus, the sum ranges from 0 to 1 and was not calculated if data for any of the terms in the sum were not available.

[3] Each of the mouthing variables in the sum has possible values 0 = Less than once per week or never, 1 = Several times a week, and 2 = Several times a day or more. Thus, the sum ranges from 0 to 1 and was not calculated if data for any of the terms in the sum were not available.

1. Model (1) in Section I4.1.1 was expanded to consider other environmental-lead measures as predictor variables that were selected by stepwise regression procedures. These measures were dust-lead loadings for both uncarpeted floors and window sills, soil-lead concentration, and paint condition (as represented by the paint pica hazard variable). Then, carpeted floor dust-lead loading was added to this expanded model in order to assess its association with blood-lead concentration after adjusting for these other predictor variables:

$$\log(PbB_i) = \mu + \sum_j \beta_j * X_{j,i} + \alpha * \log(pc_i * PbD_{carpeted,i}) + \varepsilon_i \qquad (4)$$

2. Same as #1, but the demographic variables in Table I4-1 were also included in the stepwise regression procedure as potentially significant predictor variables in the expanded model prior to adding carpeted floor dust-lead loading:

$$\log(PbB_i) = \mu + \sum_j \beta_j * X_{j,i} + \sum_k \beta_k * Z_{k,i} + \alpha * \log(pc_i * PbD_{carpeted,i}) + \varepsilon_i \qquad (5)$$

In these two models, for the ith housing unit, $X_{1,i}$ denotes the product of log-transformed area-weighted average uncarpeted floor dust-lead loading and the proportion of sampled floor-dust that was uncarpeted, $X_{2,i}$ denotes log-transformed area-weighted average window sill dust-lead loading, $X_{3,i}$ denotes log-transformed average soil-lead concentration, $X_{4,i}$ denotes paint pica hazard (Table I4-1), $Z_{k,i}$ denote the kth in a series of selected demographic variables, and the remaining terms are as defined for the previous models presented in this section.

In models (4) and (5), the area-weighted average carpeted floor dust-lead loading was multiplied by the proportion of sampled floor area that was carpeted and, as mentioned in the definition of X_1, the area-weighted average uncarpeted floor dust-lead loading was multiplied by the proportion of sampled floor area that was uncarpeted. In model (1), the relationship between blood-lead concentration and floor dust-lead loading was modeled separately for carpeted and uncarpeted floors, and observations were weighted by the proportion of sampled floor area that was carpeted (when considering carpeted floor dust-lead data) or uncarpeted (when considering uncarpeted floor dust-lead data). In models (4) and (5), carpeted and uncarpeted floor dust-lead loadings are included in the same model. Multiplying these values by the proportion of sampled floor area that was carpeted and uncarpeted, respectively, achieved a similar goal as the weighting in model (1): carpeted (uncarpeted) floor dust-lead loading measurements taken from homes where more of the floor was carpeted (uncarpeted) were given more influence in the model fit.

As soil sampling was optional in the HUD Grantees program, models (4) and (5) were fitted to the HUD Grantees data both with and without soil-lead concentration included in the list of predictor variables in the stepwise regression procedure. When fitting the model to HUD

Grantees data, separate intercepts (μ) for the different grantees were included in the pool of potential predictors but were not forced into the model. The stepwise procedure was allowed to choose which grantees had significantly different intercepts from the others.

I4.1.3 Performance Characteristics Analysis

While the model-based analyses in Sections I4.1.1 and I4.1.2 can provide useful results, these results may depend highly on the form of the model, the set of predictor variables included in the model, and how these variables were defined and measured. To reduce the level of dependence that these factors may have on the outcome of these analyses, the non-modeling, performance characteristics analysis approach documented in Section 6.1 of the §403 risk analysis supplement report was also applied to data from the two studies. (See Section 6.1 for details on the features of this approach.) Considering results of both this approach and the model-based approach can provide a more complete perspective on findings to support the analyses' common underlying objective to characterize the relationship between blood-lead concentration and carpeted floor dust-lead loading and the need for a carpet dust-lead loading standard.

Of interest in the performance characteristics analysis was how the performance of a given set of standards for lead in dust (uncarpeted floors and window sills) and soil might be improved by adding a carpeted floor dust-lead loading standard. For example, performance would improve if the carpet dust-lead loading standard triggers an intervention for some homes containing children with elevated blood-lead concentrations that had not been previously triggered by the other standards, while at the same time not triggering other homes that do not contain elevated blood-lead children. The deteriorated lead-based paint standards in the §403 proposed rule were not considered in this analysis as no measurements were made in either study that could be directly compared to these standards.

In this analysis, the performance characteristics of the §403 proposed standards (dust and soil) were initially calculated. Then, the change in performance when including a carpeted floor dust-lead loading standard was evaluated for a range of such carpet dust-lead standards. The candidate carpet standard that achieved the largest total of sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) was then identified. However, the individual characteristics were also of interest. For example, if it is particularly important to have few false positives (i.e., triggering homes that do not contain elevated blood-lead children), then one would wish to maximize specificity. On the other hand, if a classification that results in few false negatives is most desired (i.e., not triggering homes that contain elevated blood-lead children), then one would maximize sensitivity. Plots of each of the four performance characteristics and their total were provided to allow visual inspection of performance over a range of candidate carpeted floor dust-lead loading standards.

As discussed earlier, evaluating the need for a carpeted floor dust-lead loading standard must also consider situations where housing units with only carpeted floors are encountered. To evaluate the need for carpet dust-lead loading standards in this type of environment, it was desired to perform the performance characteristics analysis on data for only those housing units having exclusively carpeted floors. However, the two studies considered in these analyses did not identify homes in this manner. While homes having floor-dust samples taken only from carpets could be considered as an approximation, few such homes existed in either study. Instead, the additional performance characteristics analyses were performed on all homes, but floor dust-lead loading data were considered only for carpeted floors. The results of these analyses (which considered carpet, soil, and window sill dust standards) were then compared to the results of analyses where carpet dust-lead was not considered (i.e., only soil-lead and window sill dust-lead standards were considered) to determine if the addition of a carpeted floor standard provided any performance benefit when floor dust sampling was assumed to be entirely from carpeted floors.

Note that while this performance characteristics analysis addressed the issue of the need for a carpet dust-lead loading standard, it also addressed what this standard may be and whether it should be different from the uncarpeted floor dust-lead loading standard of 50 $\mu g/ft^2$ specified in the §403 proposed rule. These latter areas are components of the second and third objectives of this analysis, which are addressed further in Sections I4.2 and I4.3.

I4.2 DETERMINING A CARPETED FLOOR DUST-LEAD LOADING STANDARD

The results of applying the analysis method in Section I4.1.3 provide initial information on objective #2, which was to consider appropriate candidates for carpeted floor dust-lead loading standards, and in particular, whether the proposed uncarpeted floor dust-lead loading standard of 50 $\mu g/ft^2$ should be considered a candidate standard. Applying the approaches presented in this section provided additional information on addressing this objective. Three approaches are presented:

- a comparison of average dust-lead loadings between carpeted and uncarpeted floors in the same housing unit, to determine whether the two averages within a home differ significantly (Section I4.2.1)

- regression modeling to predict the blood-lead concentration at which 95% of children are expected to be below at a given floor dust-lead loading, and how this blood-lead concentration differs when the dust-lead loading is assumed to be for carpeted versus uncarpeted floors (Section I4.2.2)

- performance characteristics analyses to evaluate a carpeted floor dust-lead loading standard whose performance was similar to or better than that of the proposed standard for uncarpeted floors (Section I4.2.3).

In each of these three analyses, only data from the Rochester study were considered. As the grantees participating in the HUD Grantees program evaluation targeted homes with children at high risk for elevated blood-lead, applying these analyses to the HUD Grantees data could yield misleading conclusions when attempting to make inferences on the entire population based on the results. In contrast, the Rochester study is at best representative of a typical urban population.

I4.2.1 Comparing Average Dust-Lead Loadings Between Carpeted and Uncarpeted Floors in a Housing Unit

In this analysis, average (wipe) dust-lead loadings between carpeted and uncarpeted floors were compared within housing units having both types of floor surfaces. A paired t-test was used to make this comparison (i.e., a one-sample t-test on the differences between the log-transformed area-weighted average floor dust-lead loadings for carpeted and uncarpeted floors within a unit). This test determined whether the differences were significantly different from zero, or equivalently, whether the geometric mean of the ratio of carpeted to uncarpeted (untransformed) area-weighted averages within a unit was significantly different from one. Non-significance implied that (wipe) dust-lead loadings were similar between the two floor surfaces within a housing unit, suggesting that a dust-lead loading standard for uncarpeted floors may be reasonably implied, unchanged, to carpeted floors as well.

I4.2.2 Regression Modeling Approach

In this analysis, model (1) of Section I4.1.1.2 was fitted to the Rochester study data to predict blood-lead concentration as a function of average floor dust-lead loading for a given surface type (carpeted, uncarpeted), with separate model fittings being performed for each surface type. However, unlike the approach taken in Section I4.1.1.2, the observations included in the model fittings were not weighted. As these model fittings were used to evaluate the need for a separate dust-lead loading standards between carpeted and uncarpeted floors, an unweighted analysis was used as such standards would be compared directly to a household average and not to a weighted version.

Within each regression model fitting, an upper 95% prediction bound on blood-lead concentration was calculated over the range of average floor dust-lead loadings. Then, for a given dust-lead loading, the blood-lead concentration was identified below which 95% of the population of children exposed to that average dust-lead level would be expected to fall. The results were compared between model fits (i.e., between carpeted and uncarpeted floors). If the bound on blood-lead concentration for carpeted floors using a standard of 50 $\mu g/ft^2$ was not much higher than the bound for uncarpeted floors using that same standard, then this provided evidence that using this same standard for carpeted floor dust-lead loadings would be at least as protective of children as the same standard for uncarpeted floor dust-lead loadings.

I4.2.3 Performance Characteristics Analysis Approach

The approach taken in this performance characteristics analysis is the same as that documented in Section I4.1.3, but only average dust-lead loadings on carpeted or uncarpeted floors were compared to candidate standards when determining whether an intervention was triggered in a given housing unit (i.e., window sill dust-lead loadings and soil-lead concentrations were not considered). The analysis calculated the four performance characteristics described in Section 6.1 of the §403 risk analysis supplement report under a variety of alternative values of the dust-lead loading standard for carpeted and uncarpeted floors. Each of the four characteristics, as well as their total, were plotted versus the candidate floor dust-lead loading standards to illustrate the differences in performance of candidate standards between carpeted and uncarpeted floors. The goal was to identify a carpeted floor dust-lead loading standard whose performance in this analysis was similar to or better than that of the proposed standard of 50 $\mu g/ft^2$ for uncarpeted floors. In this way, similar levels of protection may be achieved by floor dust-lead loading standards regardless of surface type.

I4.3 DETERMINING AN APPROPRIATE METHOD FOR SAMPLING CARPET DUST

The dust-lead loading data analyzed by the methods in Sections I4.1 and I4.2 were for samples collected using wipe techniques. However, other methods have been developed for collecting dust samples as part of a risk assessment. Different dust collection methods can collect different types of dust samples containing different amounts of lead. This can have a major effect on the observed relationship between dust-lead levels in the collected samples and blood-lead concentration. Therefore, objective #3 of this analysis was to investigate how the effect of floor dust-lead levels on children's blood-lead concentration may depend on the dust collection method being used and how the results differ between carpeted and uncarpeted floors. This section documents the methods used to conduct statistical analyses on Rochester study and HUD Grantees evaluation data in support of this objective. Other studies that have investigated these issues and their findings have been documented in USEPA, 1997a.

Floor dust-lead data for samples collected using the BRM vacuum, DVM vacuum, and wipe techniques exist within the Rochester study database. For the HUD Grantees program evaluation, only wipe dust-lead loading data were available for both carpeted and uncarpeted floors, while very limited data on DVM dust-lead loadings for carpeted floors were collected.

I4.3.1 Investigating the Association Between Floor Dust-Lead Levels and Blood-Lead Concentration for Different Sampling Methods

Pearson correlation coefficients between average dust-lead levels and blood-lead concentration were computed for BRM and DVM vacuum sampling and for wipe sampling, for both dust-lead loading and concentration and for both carpeted and uncarpeted floors. Then, univariate regressions of blood-lead concentration on average floor dust-lead, using model (1) of Section I4.1.1.2, were fitted to data for all three dust collection methods according to each combination of measurement type (loading, concentration) and surface type (carpeted, uncarpeted). In the correlation and regression analyses, dust-lead data for a given household were weighted by the percent of total floor sample area for the given dust collection method that was carpeted (or uncarpeted, depending on the model fit).

I4.3.2 Determining the Relationships of Average Dust-Lead Levels Between Sampling Methods

This analysis investigated how dust-lead levels, as well as the relationship between dust-lead loadings and concentrations, differed between dust collection methods and how these comparisons differed between carpeted and uncarpeted floors. This analysis was performed only on Rochester study data, as the HUD Grantees evaluation had virtually all carpet dust samples collected via wipe methods.

This analysis made statistical comparisons between the following pairs of dust-lead measurements, with each comparison being done separately for carpeted and uncarpeted floors (i.e., a total of 6x2=12 comparisons):

- Average BRM dust-lead loading versus average DVM dust-lead loading
- Average BRM dust-lead concentration versus average DVM dust-lead concentration
- Average BRM dust-lead loading versus average wipe dust-lead loading
- Average DVM dust-lead loading versus average wipe dust-lead loading
- Average BRM dust-lead loading versus average BRM dust-lead concentration
- Average DVM dust-lead loading versus average DVM dust-lead concentration

Each comparison consisted of plotting the data, then calculating Pearson correlation coefficients on the log-transformed data to evaluate the linear relationship between the two (log-transformed) measurements. When calculating the Pearson correlation coefficients, each data point was weighted by the proportion of total floor area in the housing unit sampled by the given dust collection methods that corresponded to the particular surface type (carpeted or uncarpeted). For example, when calculating the correlation coefficient between BRM and DVM carpet dust-lead loadings, each data point was weighted by the proportion of total floor area sampled by the BRM and DVM that was carpeted. Each calculated correlation coefficient was tested for significant difference from zero. The results for carpeted surfaces were then compared to those for uncarpeted surfaces.

I4.3.3 Investigating the Relationship in Lead Loadings of Side-by-Side Dust Samples Collected by Different Methods

The Rochester study sampling design included taking dust samples from three adjoining (side-by-side) areas, where each dust collection method (BRM, DVM, wipe) was used to collect one of the three samples. In this analysis, it was of interest to determine how measured dust-lead loadings differed among side-by-side samples (and, therefore, among different dust collection methods). This comparison was based on within-location variability (as well as sampling and analysis variability), as opposed to the unit-to-unit variability used to make comparisons in the analyses described in the previous subsections. The analysis was done on data for carpeted surfaces and uncarpeted surfaces separately, allowing for comparisons between the two surface types. This analysis was performed only on Rochester study data, as the HUD Grantees program evaluation did no side-by-side sampling.

In the Rochester study, floor-dust samples were identified according to the room in which they were collected and the collection method used; the dust samples within a room were assumed to be collected from adjacent, side-by-side areas. The lead loading data for these samples were used in fitting the following regression model to predict the dust-lead loading under one dust collection method (method A) as a function of the loading under a second method (method B):

$$\log(PbDA_{ij}) = \mu + \alpha * \log(PbDB_{ij}) + H_i + \varepsilon_{ij} \qquad (6)$$

where $PbDA_{ij}$ is the dust-lead loading for the floor-dust sample collected by method A in the jth room within the ith housing unit, $PbDB_{ij}$ is the dust-lead loading for the floor-dust sample collected by method B at the jth room within the ith housing unit, and H_i is the random effect of the ith housing unit on $PbDA_{ij}$. Thus, model (6) was used to predict the dust-lead loading for a sample under one collection method as function of the observed dust-lead loading for the adjacent sample of another collection method. The model controls for two types of variation: variation due to sampling in different housing units, and variation due to sampling in different rooms within a housing unit. As it was desired to express the dust-lead loading under one method as a function of the observed dust-lead loading of another method, the model fitting did not adjust for measurement error in the dependent variable.

For every dust collection method that was assigned as method A, model (6) above was fitted four times, once for each combination of surface type (carpeted floors, uncarpeted floors) and for the remaining two dust collection methods that could be assigned as method B.

In model (6) above, the intercept μ represents a constant underlying multiplicative bias in the results of the two collection methods, while the slope α represents the extent to which the bias is constant across the range of loadings. Intercepts significantly different from zero suggest the presence of a bias, while slopes significantly different from one suggest that the bias changes with the magnitude of the measurements. Therefore, the estimates of the intercept and slope parameters are reported for each model fitting, as well as results of significance tests.

A more statistically rigorous procedure for converting dust-lead loadings from one dust collection method to another is found in USEPA, 1997c.

I5.0 RESULTS

Detailed results of the statistical methods documented in Section I4 as applied to data from the Rochester study and the HUD Grantees program evaluation (Section I3) are presented in this section. To allow the reader to easily refer to details on the statistical methods behind a particular set of results, the sections and subsections within this section are titled and organized in the same way as in Section I4, where the methods were presented. Each subsection (Sections I5.1 through I5.3) corresponds to one of the three appendix objectives presented in Section I1.2. Conclusions made from these results are found in Section 6.5 of the §403 risk analysis supplement report.

Note that individual results presented in this section may differ from similar results presented in previously-published documents on these two studies. This is due to differences in the statistical methods used in this appendix, in the subsets of data included in the analysis, and in any transformations and summary calculations performed on the data prior to analysis.

Descriptive statistics of the data analyzed in this section are presented in Appendix I2.

I5.1 ASSESSING THE NEED FOR A CARPETED FLOOR DUST-LEAD STANDARD

See Section I4.1 and its subsections for details on the statistical methods associated with the results presented in this section.

I5.1.1 Investigating the Association Between Dust-Lead Loading and Blood-Lead Concentration for Carpeted and Uncarpeted Floors

I5.1.1.1. Correlations Between Floor Dust-Lead Loading and Blood-Lead Concentration. Figure I5-1 contains four plots, each depicting blood-lead concentration versus household average (wipe) floor dust-lead loading for each combination of surface type (carpeted, uncarpeted) and study. Each point within the plots represents a single housing unit.

The plots in Figure I5-1 show some positive correlation between dust-lead loadings and blood-lead concentration, but the level of variability in these relationships is high for both studies and surface types.

For each plot in Figure I5-1, a Pearson correlation coefficient was calculated on the data in the plot to quantify the extent of a linear relationship between log-transformed blood-lead concentration and log-transformed average floor dust-lead loading. The correlation coefficients for each study and particular surface type (carpet, uncarpeted) are presented in Table I5-1. This table indicates the following:

- For the Rochester study, statistically significant correlation was observed at the 0.01 level between blood-lead concentration and average dust-lead loading when sampling from uncarpeted floors and at the 0.05 level when sampling from carpeted floors.

- For the HUD Grantees program evaluation, statistically significant correlations were observed at the 0.01 level between blood-lead concentration and average dust-lead loading when sampling from both carpeted and uncarpeted floors.

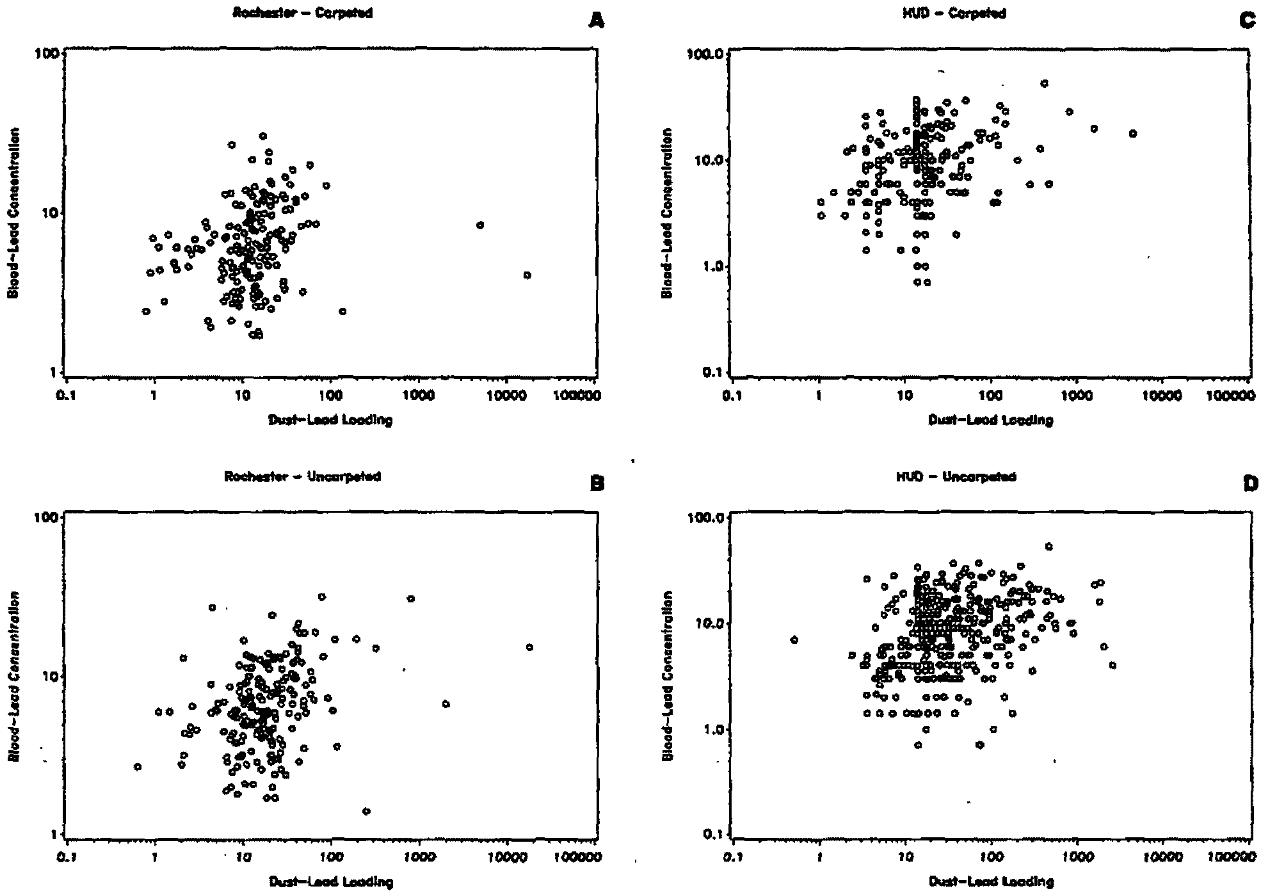

Figure I5-1. Plots of Blood-Lead Concentration versus Household Average (Wipe) Floor Dust-Lead Loading, for Each Combination of Floor Surface Type (Carpeted, Uncarpeted) and Study

Table I5-1. Pearson Correlation Coefficients of Log-Transformed Average (Wipe) Dust-Lead Levels with Log-Transformed Blood-Lead Concentration, for Carpeted and Uncarpeted Floors

Surface Type	Rochester Study	HUD Grantees Program Evaluation
Carpeted Floors [1]	0.190* (179)	0.308** (226)
Uncarpeted Floors [1]	0.313** (193)	0.335** (390)

[1] Correlation coefficients are calculated on unit-wide area-weighted average dust-lead loadings, where averages are taken across all samples in a housing unit of the given surface type (carpet or non-carpet). The average for a given housing unit is weighted by the proportion of total floor wipe sample area in the unit represented by carpeted (uncarpeted) surfaces in calculating the correlation coefficient for carpeted (uncarpeted) floors.

* Significant at the 0.05 level.

** Significant at the 0.01 level.

Results in Table I5-1 differ slightly from correlation coefficients reported in the Rochester study report (the Rochester School of Medicine and NCLSH, 1995), primarily due to the form of the dust-lead parameter (this analysis used a log-transformed weighted arithmetic average of untransformed data, while the Rochester study report used an untransformed unweighted average of log-transformed data).

I5.1.1.2. <u>Univariate Regression of Blood-Lead Concentration on Floor Dust-Lead Loading</u>. To further investigate the relationship between floor dust-lead loading and blood-lead concentration, model (1) in Section I4.1.1.2 was fitted separately to each set of data determined by the four plots in Figure I5-1. Table I5-2 presents the estimated slope and intercept terms for the two model fits to the Rochester data, and the estimated slope terms for the two model fits to the HUD Grantees evaluation data. (Recall that the latter two model fits had grantee-specific intercepts, whose estimates are not included in Table I5-2). Table I5-2 also includes the standard errors associated with each estimate. The column marked "baseline" in Table I5-2 is the exponentiation of the intercept term (for the Rochester study data fits) and represents a baseline geometric mean blood-lead concentration before any floor dust-lead effects impact the value. Statistically significant slope estimates (denoted by asterisks in Table I5-2) imply that the predictor variable is significantly associated with blood-lead concentration.

Table I5-2. Estimates of Intercept and Slope Parameters (and their Standard Errors) Associated With Regression Models That Predict Blood-Lead Concentration Based on Average (Wipe) Floor Dust-Lead Loading

Study	Floor Surface Type	Number of Units	Estimates (Standard Errors)		
			Intercept (μ)	Baseline (e^{μ}; μg/dL)	Slope (α)
Rochester Study [1]	Carpeted	179	1.53 (0.11)	4.61	0.103* (0.040)
	Uncarpeted	193	1.39 (0.12)	4.03	0.174** (0.038)
HUD Grantees Program Evaluation [2]	Carpeted	226			0.160** (0.048)
	Uncarpeted	390			0.117** (0.030)

[1] The regression model takes the form $\log(PbB_i) = \mu + \alpha(\log(PbD_i)) + \epsilon_i$, or equivalently, $PbB_i = \exp(\mu) \times (PbD_i)\alpha \times \exp(\epsilon_i)$, where PbB_i is the blood-lead concentration for the child in the ith housing unit, ϵ_i refers to the random error associated with the model-based blood-lead concentration for the ith unit, and remaining notation is specified in the column headings. For a specific surface type, results for the ith unit are weighted by the proportion of total floor sampling area represented by the given surface type.

[2] The regression model takes the form $\log(PbB_{ij}) = \gamma_j + \alpha^*\log(PbD_{ij}) + \epsilon_{ij}$, where PbB_{ij} represents the blood-lead concentration for the selected child in the ith housing unit within the jth grantee, PbD_{ij} corresponds to the observed average floor dust-lead loading for the ith housing unit within the jth grantee (for the given surface type), and α and γ_j are parameters representing the slope of the model and the intercept for the jth grantee, respectively. The residual error left unexplained by the model is denoted by ϵ_{ij}. The model is weighted by the proportion of total floor sampling area represented by the given surface type.

* Significantly different from zero at the 0.05 level.
** Significantly different from zero at the 0.01 level.

Results from Table I5-2 are as follows:

- For each model fit, the slope estimate was positive and statistically different from zero at the 0.05 level, implying that increased blood-lead concentrations were significantly associated with increased values of the dust-lead predictor variable.

- For the Rochester study, dust-lead loadings were significant predictors of blood-lead concentration for carpeted floors at the 0.05 level (p-value = 0.0110) and for uncarpeted floors at the 0.01 level (p-value ≤ 0.0001).

- For the HUD Grantees program evaluation, dust-lead loadings were significant predictors of blood-lead concentration at the 0.01 level for both carpeted (p-value = 0.0010) and uncarpeted (p-value ≤ 0.0001) floors.

Therefore, the results of this analysis indicate that dust-lead loadings from both carpeted and uncarpeted floors are statistically significant predictors of blood-lead concentration, in the absence of other potentially significant (and possibly confounding) predictors. The same conclusion holds whether one considers data from the Rochester study or the HUD Grantees program evaluation.

I5.1.1.3. Comparing the Dust-Lead Loading/Blood-Lead Concentration Relationship Between Homes With Mostly Carpeted Floors and Homes With Mostly Uncarpeted Floors. To illustrate whether the relationship between blood-lead concentration and floor dust-lead loading differs significantly between homes that are mostly carpeted (i.e., more than 50% of the total floor area wipe-sampled for dust is carpeted) and homes that are mostly uncarpeted, Table I5-3 presents the results of fitting model (2) of Section I4.1.1.3 according to the procedures specified in that section. Recall from Section I4.1.1.3 that the dust-lead loading variable in model (2) had one of two possible definitions: the average floor dust-lead loading based on samples taken only from the surface type with the higher total sample area ("surface majority"), and a weighted average of the average carpeted and uncarpeted floor dust-lead loadings ("weighted average").

The key results in Table I5-3 are found within the columns labeled "β_0" and "β_1", as these model parameters represent whether the intercept and slope parameters in the model differ between homes having floor dust samples collected from mostly carpeted floors and homes having floor dust samples collected from mostly uncarpeted floors. Note that none of the rows of Table I5-3 indicate that the estimates of β_0 and β_1 are significantly different from zero. The results in Table I5-3 suggest that for each study, regardless of whether the floor dust-lead loading variable follows the "surface majority" or "weighted average" definition in this analysis, there is no statistically significant difference in the relationship between blood-lead concentration and average floor dust-lead loading between houses with mostly carpeted floors and houses with mostly uncarpeted floors. This supports the hypothesis that carpeted and uncarpeted floor dust-lead loadings predict blood-lead concentration in a similar manner.

Table I5-3. Estimates of Intercept and Slope Parameters (and Their Standard Errors) Associated With Fitting Model (2) to Predict Blood-Lead Concentration Based on an Average (Wipe) Floor Dust-Lead Loading Which Emphasizes the Floor Surface Type With the Larger Sample Area

Study	Definition of Dust-Lead Variable	# Units	Estimate (Standard Error)			
			Intercept (μ)	Change in Intercept for Units Having > 50% Floor-Dust Samples from Carpets (β_0)	Slope (α)	Change in Slope for Units Having > 50% Floor-Dust Samples from Carpets (β_1)
Rochester Study [1]	Surface Majority	142	1.627** (0.262)	-0.281 (0.335)	0.137 (0.078)	0.025 (0.108)
	Weighted Average		1.538** (0.274)	-0.314 (0.353)	0.170* (0.085)	0.036 (0.116)
HUD Grantees Program Evaluation [2]	Surface Majority	363		-0.111 (0.264)	0.124** (0.034)	0.057 (0.082)
	Weighted Average			-0.063 (0.271)	0.135** (0.037)	0.032 (0.084)

[1] The regression model takes the form $\log(PbB_i) = \mu + \alpha^*\log(PbD_i^*) + \beta_0{}^*SURF_i + \beta_1{}^*\log(PbD_i^*)^*SURF_i + \epsilon_i$, where PbB_i is the blood-lead concentration for the child in the ith housing unit, PbD_i^* is the dust-lead loading variable as defined in Section I4.1.1.3 in the ith unit, $SURF_i$ equals one if floors were sampled mostly from carpets in the ith unit, and zero if floor-dust sampling was mostly from uncarpeted surfaces, ϵ_i refers to the random error associated with the model-based blood-lead concentration for the ith unit, and remaining notation is specified in the column headings.

[2] The regression model takes the form $\log(PbB_{ij}) = \gamma_j + \alpha^*\log(PbD_{ij}^*) + \beta_0{}^*SURF_{ij} + \beta_1(\log(PbD_{ij}^*)^*SURF_{ij} + \epsilon_{ij}$ where PbB_{ij} represents the blood-lead concentration for the selected child in the ith housing unit within the jth grantee, PbD_{ij}^* corresponds to the observed floor dust-lead loading as defined in Section I4.1.1.3 for the ith housing unit within the jth grantee, and α and γ_j are parameters representing the slope of the model and the intercept for the jth grantee, respectively. The residual error left unexplained by the model is denoted by ϵ_{ij}. $SURF_{ij}$ equals one if floors were sampled mostly from carpets, and zero if floor-dust sampling was mostly from uncarpeted surfaces in the ith unit within the jth grantee. Remaining notation is specified in the column headings.

* Significantly different from zero at the 0.05 level.
** Significantly different from zero at the 0.01 level.

I5.1.1.4. __Investigating the Association Between Floor Dust-Lead Loading and Blood-Lead Concentration, Controlling for Demographic Variables__. The previous sections investigated the association between floor dust-lead loading and blood-lead concentration without considering the effects on blood-lead concentration of other potentially influential variables. In this section, model (3) from Section I4.1.1.4 was fitted to the study data, which extends model (1) used to generate the results in Section I5.1.1.2 above by adding other potentially influential demographic variables as predictor variables using stepwise regression techniques. The effect of average dust-lead loading on blood-lead concentration was assessed only after taking into account the effects of these other demographic variables (which do not represent the set of all such important variables). See Table I4-1 for a listing and definitions of the demographic variables considered in this analysis.

Tables I5-4 and I5-5 present the results of fitting model (3) to the Rochester study data and the HUD Grantees program evaluation data, respectively. The tables list those demographic variables from Table I4-1 that were selected for the model due to having significant effects on blood-lead concentration data, along with their corresponding slope estimates. The slope estimates corresponding to average dust-lead loading is in the last row of these tables, as this variable was added last to model (3).

Both analyses concluded that regardless of whether carpeted or uncarpeted floors were being considered, average floor dust-lead loading was a statistically significant predictor of blood-lead concentration even after adjusting for other important demographic variables, with an increase in floor dust-lead loading associated with an increase in blood-lead concentration. Other findings when analyzing the Rochester study data (Table I5-4) included the following:

- The race, sex, and education variables (Table I4-1) were statistically significant predictors of blood-lead concentration.

- When dust-lead loadings from only carpeted floors were considered, mouthing behavior (putting mouth on window sill, use of pacifier, soil pica, thumb-sucking) was a statistically significant predictor of blood-lead concentration, with a greater propensity of mouthing behavior corresponding to higher blood-lead concentration.

- When dust-lead loadings from only uncarpeted floors were considered, paint/pica hazard was a statistically significant predictor of blood-lead concentration with a larger potential for paint pica hazard corresponding to higher blood-lead concentration.

Other findings when analyzing the HUD Grantees evaluation data (Table I5-5) included the following:

- More differences among the grantee-specific intercepts were observed when dust-lead loadings were considered for uncarpeted floors versus carpeted floors. Note, however, that the model fitting which considered carpeted floor dust-lead loadings involved data for 161 fewer housing units, as some grantees had few or no carpeted floor dust-lead loading data.

- When dust-lead loadings from only carpeted floors were considered, the only significant demographic variable other than grantee differences was the seasonality variable, with measurements in spring and summer associated with larger values of blood-lead concentration.

- When dust-lead loadings from only uncarpeted floors were considered, income, race, and mouthing behavior were found to be statistically significant predictors of blood-lead concentration.

Table I5-4. Parameter Estimates (and their Standard Errors) Associated With Fitting Model (3) to Rochester Study Data to Predict Blood-Lead Concentration Based on Average Floor Dust-Lead Loading

Carpeted Floor Dust			Uncarpeted Floor Dust		
Parameter	Estimate (Std. Error)	P-value	Parameter	Estimate (Std. Error)	P-value
Parameters Selected by Stepwise Regression[1]					
Intercept	1.843 (0.121)	≤0.0001	Intercept	1.787 (0.133)	≤0.0001
Race	-0.430 (0.089)	≤0.0001	Race	-0.322 (0.101)	0.0018
Sex	-0.614 (0.154)	≤0.0001	Sex	-0.513 (0.194)	0.0091
Education	-0.300 (0.088)	0.0009	Education	-0.188 (0.100)	0.0626
Mouthing Behavior	0.536 (0.262)	0.0428	Paint Pica Hazard	0.441 (0.152)	0.0042
Parameter Added Last					
Log Floor Dust-Lead Loading	0.087 (0.034)	**0.0117**	Log Floor Dust-Lead Loading	0.101 (0.037)	**0.0065**
R^2 of final model: 0.334 Number of data points (housing units): 176			R^2 of final model: 0.277 Number of data points (housing units): 192		

(see footnote below)

Table I5-5. Parameter Estimates (and their Standard Errors) Associated With Fitting Model (3) to Data from the HUD Grantees Program Evaluation to Predict Blood-Lead Concentration Based on Average Floor Dust-Lead Loading

Carpeted Floor Dust			Uncarpeted Floor Dust		
Parameter	Estimate (Std. Error)	P-value	Parameter	Estimate (Std. Error)	P-value
Parameters Selected by Stepwise Regression[1]					
Intercept	1.628 (0.163)	≤0.0001	Intercept	1.83 (0.131)	≤0.0001
California	-0.730 (0.259)	0.0052	California	-0.899 (0.174)	≤0.0001
Cleveland	0.326 (0.133)	0.0152	Cleveland	0.231 (0.136)	0.0896
New York City	-0.400 (0.218)	0.0673	New York City	-0.597 (0.141)	≤0.0001
Minnesota	-0.348 (0.120)	0.0042	Alameda County	-0.505 (0.116)	≤0.0001
Season	0.217 (0.104)	0.0378	Baltimore	-0.225 (0.108)	0.0375
			Vermont	0.518 (0.218)	0.0180
			Income	-0.180 (0.071)	0.0123
			Race	-0.317 (0.091)	0.0005
			Mouthing	0.191 (0.091)	0.0364
Parameter Added Last					
Log Floor Dust-Lead Loading	0.160 (0.046)	**0.0006**	Log Floor Dust-Lead Loading	0.110 (0.029)	**0.0002**
R^2 of final model: 0.246 Number of data points (housing units): 226			R^2 of final model: 0.290 Number of data points (housing units): 387		

[1] Parameters are accepted into the model with a significance level (adjusted for other terms in the model) of 0.10 or lower and are removed from the model when their significance level (adjusted for other terms in the model) is higher than 0.10.

Note that these analyses ignored the contribution to the prediction of blood-lead concentration made by other environmental-lead variables such as soil-lead concentration and window sill dust-lead loading. The next section will address effects in the presence of these additional variables.

I5.1.2 Investigating the Association Between Carpeted Floor Dust-Lead Loading and Blood-Lead Concentration, Controlling for Other Environmental-Lead Sampling

To investigate the contribution that average carpeted floor dust-lead loading may have on predicting blood-lead concentration, over and above the contributions of the lead measures (uncarpeted floor dust, window sill dust, soil-lead concentration) that can be compared to the current §403 standards, models (4) and (5) of Section I4.1.2 were fitted to the Rochester and HUD Grantees data. As described in Section I4.1.2, stepwise regression procedures were used to select predictor variables, with the candidate predictor variables corresponding to uncarpeted floor dust-lead loading, window sill dust-lead loading, soil-lead concentration, and paint pica hazard for model (4), and these variables plus the demographic variables in Table I4-1 for model (5). Once these other variables were selected for the model, the carpeted floor dust-lead loading variable was added to the model. Data for only those housing units having floor dust-lead loading data for both carpeted and uncarpeted surfaces were included in this analysis.

Tables I5-6a and I5-6b present the results of fitting models (4) and (5), respectively, to data from the Rochester study. According to these tables, once the effects of other important factors were accounted for in both models, the additional effect of average carpeted dust-lead loading on blood-lead concentration was not statistically significant. (Both p-values were considerably higher than 0.10.) In contrast, soil-lead concentration and uncarpeted dust-lead loadings had highly significant effects on blood-lead concentration in both model fits.

Tables I5-7a and I5-7b present the results of fitting models (4) and (5), respectively, to data from the HUD Grantees program evaluation. Recall that since soil sampling was optional in this evaluation, the models were fitted both with and without considering soil-lead concentration as a candidate predictor variable. In contrast to the findings of the Rochester data analysis (Tables I5-6a and I5-6b), once the effects of other important factors (including soil-lead concentration) were accounted for in the models, the additional effect of average carpeted dust-lead loading on blood-lead concentration was significant at the 0.05 level. When soil-lead concentration was excluded from the models, the additional effect of average carpeted dust-lead loading on blood-lead concentration achieved statistical significance at the 0.10 level but not at the 0.05 level.

Thus, the analyses involving models (4) and (5) provide disparate results between the two studies concerning the significance of any added effect that carpeted floor dust-lead loading may have on blood-lead concentration once the effects of other important environmental-lead and demographic predictors have been taken into account. While this may suggest that the role of lead in carpet dust on increased blood-lead concentration in children may be marginal, one must

Table I5-6a. Parameter Estimates (and their Standard Errors) Associated With Fitting Model (4) to Rochester Study Data to Predict Blood-Lead Concentration Based on Average Carpeted Floor Dust-Lead Loading After Adjusting for Other Environmental Sampling

Parameter	Estimate (Standard Error)	P-value[1]
Parameters Selected by Stepwise Regression[2]		
Intercept	0.371 (0.251)	0.1417
Log Soil-Lead Concentration	0.107 (0.038)	0.0052
Log Window Sill Dust-Lead Loading	0.074 (0.037)	0.0486
Log Floor Dust-Lead Loading (Uncarpeted)	0.257 (0.064)	0.0001
Paint Pica Hazard	0.372 (0.167)	0.0271
Parameter Added Last		
Log Floor Dust-Lead Loading (Carpeted)	0.015 (0.059)	**0.7938**
R^2 of final model: 0.287. Number of data points (housing units): 152		

[1] A p-value of 0.0001 indicates a p-value of ≤ 0.0001.
[2] Parameters were accepted into the model with a significance level (adjusted for other terms in the model) of 0.10 or lower and were removed from the model when their significance level (adjusted for other terms in the model) exceeded 0.10.

Table I5-6b. Parameter Estimates (and their Standard Errors) Associated With Fitting Model (5) to Rochester Study Data to Predict Blood-Lead Concentration Based on Average Carpeted Floor Dust-Lead Loading After Adjusting for Other Environmental and Demographic Variables

Parameter	Estimate (Standard Error)	P-value[1]
Parameters Selected by Stepwise Regression[2]		
Intercept	0.624 (0.267)	0.0207
Log Soil-Lead Concentration	0.117 (0.033)	0.0004
Log Floor Dust-Lead Loading (Uncarpeted)	0.223 (0.053)	0.0001
Race	-0.441 (0.077)	0.0001
Paint/Pica Hazard	0.243 (0.156)	0.1216[3]
Age[4]	0.178 (0.086)	0.0411
Parameter Added Last		
Log Floor Dust-Lead Loading (Carpeted)	0.037 (0.050)	**0.4657**
R^2 of final model: 0.399. Number of data points (housing units): 157		

[1] A p-value of 0.0001 indicates a p-value of ≤ 0.0001.
[2] Parameters were accepted into the model with a significance level (adjusted for other terms in the model) of 0.10 or lower and were removed from the model when their significance level (adjusted for other terms in the model) exceeded 0.10.
[3] These variables had a p-value ≤ 0.10 prior to adding Log Floor Dust-Lead Loading (Carpeted)), but their p-value exceeded 0.10 when Log Floor Dust-Lead Loading (Carpeted) was added to the model and when age was added to the model rather than age-squared.
[4] The stepwise procedure chose age-squared rather than age, but age was added to the model instead.

Table I5-7a. Parameter Estimates (and their Standard Errors) Associated With Fitting Model (4) to HUD Grantees Evaluation Data to Predict Blood-Lead Concentration Based on Average Carpeted Floor Dust-Lead Loading After Adjusting for Other Environmental Sampling

Soil-Lead Concentration Included as a Possible Predictor Variable			Soil-Lead Concentration Excluded as a Possible Predictor Variable		
Parameter	Estimate (Std. Error)	P-value	Parameter	Estimate (Std. Error)	P-value
Parameters Selected By Stepwise Regression[1]					
Intercept	0.091 (0.711)	0.8985	Intercept	1.440 (0.234)	≤0.0001
Log Soil-Lead Concentration	0.288 (0.099)	0.0061			
			Log Window Sill Dust-Lead Loading	0.031 (0.031)	0.3265 [2]
			Log Floor Dust-Lead Loading (Uncarpeted)	0.133 (0.055)	0.0167
			California	-0.784 (0.264)	0.0034
Cleveland	0.037 (0.290)	0.8999 [2]	Cleveland	0.479 (0.144)	0.0011
Minnesota	0.215 (0.311)	0.4932 [2]			
			New York City	-0.204 (0.245)	0.4044 [2]
Parameter Added Last					
Log Floor Dust-Lead Loading (Carpeted)	0.215 (0.093)	0.0260	Log Floor Dust-Lead Loading (Carpeted)	0.143 (0.074)	0.0541
R^2 of final model: 0.330 Number of data points (housing units): 42			R^2 of final model: 0.180 Number of data points (housing units): 220		

[1] Parameters were accepted into the model with a significance level (adjusted for other terms in the model) of 0.10 or lower and were removed from the model when their significance level (adjusted for other terms in the model) exceeded 0.10.
[2] These variables had a p-value ≤ 0.10 prior to adding Log Floor Dust-Lead Loading (Carpeted)), but their p-value exceeded 0.10 when Log Floor Dust-Lead Loading (Carpeted) was added to the final model.

Table I5-7b. Parameter Estimates (and their Standard Errors) Associated With Fitting Model (5) to HUD Grantees Evaluation Data to Predict Blood-Lead Concentration Based on Average Carpeted Floor Dust-Lead Loading After Adjusting for Other Environmental and Demographic Variables

Soil-Lead Concentration Included as a Possible Predictor Variable			Soil-Lead Concentration Excluded as a Possible Predictor Variable		
Parameter	Estimate (Std. Error)	P-value	Parameter	Estimate (Std. Error)	P-value
Parameters Selected By Stepwise Regression[1]					
Intercept	-0.174 (0.792)	0.8277	Intercept	1.770 (0.274)	≤0.0001
Log Soil-Lead Concentration	0.298 (0.100)	0.0053			
			Log Window Sill Dust-Lead Loading	0.023 (0.032)	0.4657 [3]
			Log Floor Dust-Lead Loading (Uncarpeted)	0.117 (0.056)	0.0382
			California	-0.777 (0.266)	0.0039
Cleveland	0.103 (0.304)	0.7377 [2]	Cleveland	0.421 (0.149)	0.0053
Minnesota	0.275 (0.322)	0.3982 [2]			
			New York City	-0.270 (0.251)	0.2827 [2]
			Rhode Island	0.368 (0.220)	0.0961
			Vermont	0.374 (0.362)	0.3030 [2]
Mouthing	0.222 (0.286)	0.4425 [2]			
			Income	-0.119 (0.110)	0.2806 [2]
			Race	-0.241 (0.126)	0.0576
			Age [3]	-0.044 (0.035)	0.2181 [2]
Parameter Added Last					
Log Floor Dust-Lead Loading (Carpeted)	0.203 (0.094)	0.0379	Log Floor Dust-Lead Loading (Carpeted)	0.137 (0.074)	0.0663
R^2 of final model: 0.342 Number of data points (housing units): 42			R^2 of final model: 0.213 Number of data points (housing units): 218		

[1] Parameters were accepted into the model with a significance level (adjusted for other terms in the model) of 0.10 or lower and were removed from the model when their significance level (adjusted for other terms in the model) exceeded 0.10.
[2] These variables had a p-value ≤ 0.10 prior to adding Log Floor Dust-Lead Loading (Carpeted)), but their p-value exceeded 0.10 when Log Floor Dust-Lead Loading (Carpeted) was added to the model and when age was added to the model rather than age-squared.
[3] The stepwise procedure chose age-squared rather than age, but age was added to the model instead.

keep in mind that differences in the types and definitions of variables measured between the two studies (i.e., candidates for predictor variables in these models) also play a key role in the outcome of the model fits.

I5.1.3 Performance Characteristics Analyses

As discussed in Section I4.1.3, the results presented in this subsection are based on a non-modeling analysis approach whose objective was to evaluate the need to add a carpet (wipe) dust-lead loading standard to the set of dust and soil standards in the §403 proposed rule (i.e., 50 $\mu g/ft^2$ for uncarpeted floors, 250 $\mu g/ft^2$ for window sills, 2000 ppm for soil), and to investigate possible recommended values for such a standard. Section 6.1 of the §403 risk analysis supplement report defines the four performance characteristics (sensitivity, specificity, positive predictive value, negative predictive value) which were the focus of this analysis and how they are calculated and interpreted.

The four performance characteristics (expressed as percentages) were calculated over a range of candidate carpet dust-lead loading standards from 0 to 100 $\mu g/ft^2$, where the carpet standard was added to the set of dust (uncarpeted floors, window sills) and soil standards from the §403 proposed rule. (Recall that the proposed paint standards were not considered in this analysis.) The results are plotted as "performance curves" within Figures I5-2 (based on Rochester study data) and I5-3 (based on HUD Grantees evaluation data). These two figures each contain six plots: one for each of the four performance characteristics, one for the sum of the four performance characteristics, and one containing the four performance characteristics superimposed on the same plot. (The vertical axis labels distinguish the plots from each other.)

Each plot in Figures I5-2 and I5-3 contains a horizontal dashed line which denotes the calculated value of the given performance characteristic when no candidate carpet dust-lead loading standard is considered. When the performance curve lies above this horizontal dashed line, this implies that any of the corresponding values of the carpet dust-lead loading standards, when added to the set of dust and soil standards in the §403 proposed rule, would result in a higher value of the given performance characteristic, and therefore, improved performance based on this performance criterion. Each plot in Figures I5-2 and I5-3 contains a vertical dashed line at 50 $\mu g/ft^2$ (i.e., the proposed standard for uncarpeted floors) to illustrate the value of the performance characteristic if both the carpeted and uncarpeted floor dust-lead loading standards were set equal to 50 $\mu g/ft^2$. An additional vertical dashed line is provided at the candidate carpet dust-lead loading standard that leads to the maximum value of the sum of the four performance characteristics: 17 $\mu g/ft^2$ based on analysis of the Rochester study data (Figure I5-2) and 5 $\mu g/ft^2$ based on analysis of the HUD Grantees evaluation data (Figure I5-3), thereby representing a possibly "optimal" value for the standard. An additional vertical dashed line is provided at 13 $\mu g/ft^2$ within the plots in Figure I5-3, for reasons to be discussed later in this section.

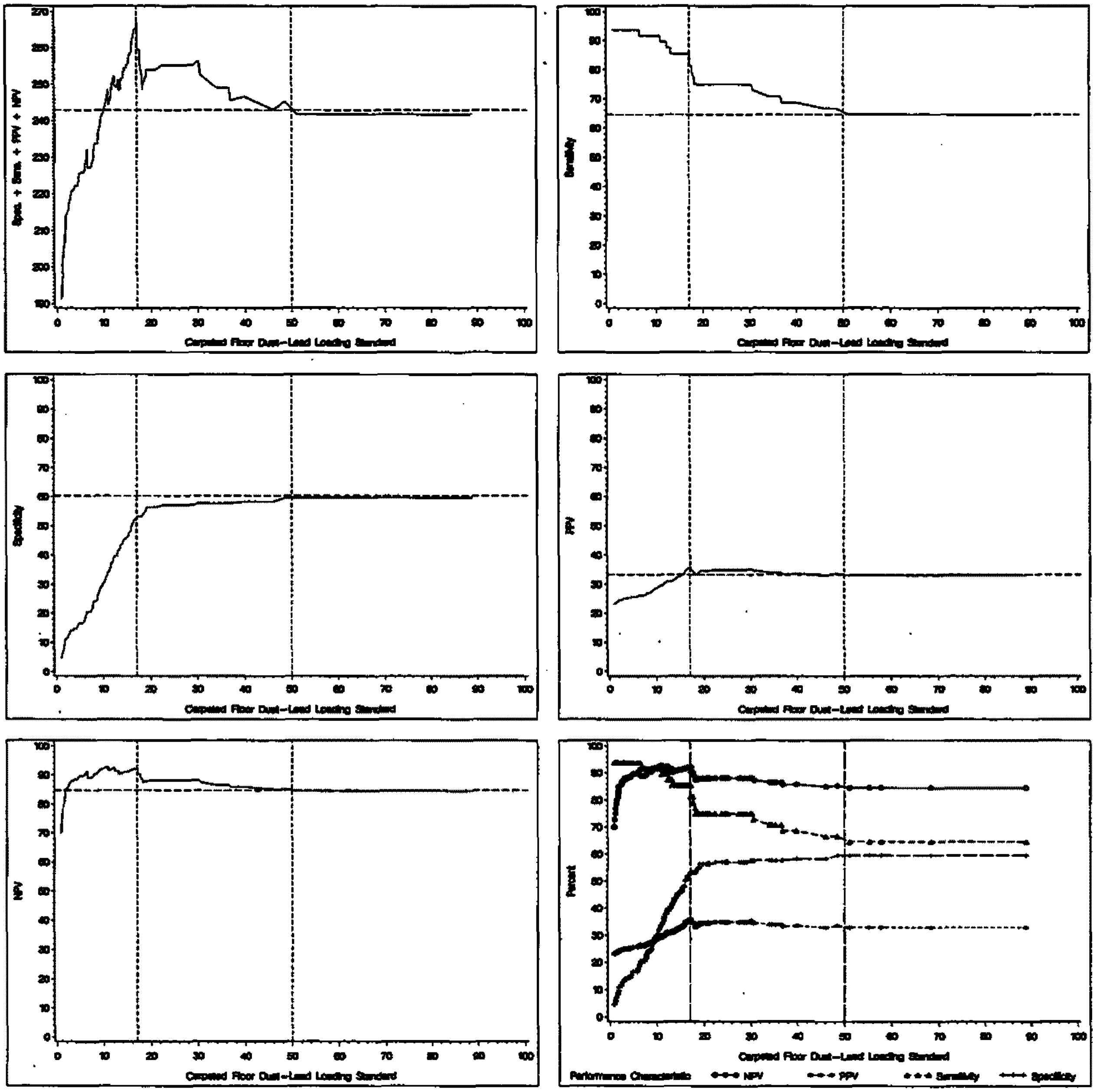

Figure I5-2. Values of the Performance Characteristics As a Function of Candidate Carpeted Floor Dust-Lead Loading Standards, Based on Analysis of the Rochester Study Data, Where the Set of Standards Also Includes the Uncarpeted Floor, Window Sill, and Soil Standards Proposed in the §403 Proposed Rule

(See text for the connotations of the horizontal and vertical dashed lines in these plots. The §403 proposed standards were 50 $\mu g/ft^2$ for uncarpeted floors, 250 $\mu g/ft^2$ for window sills, and 2000 ppm for soil.)

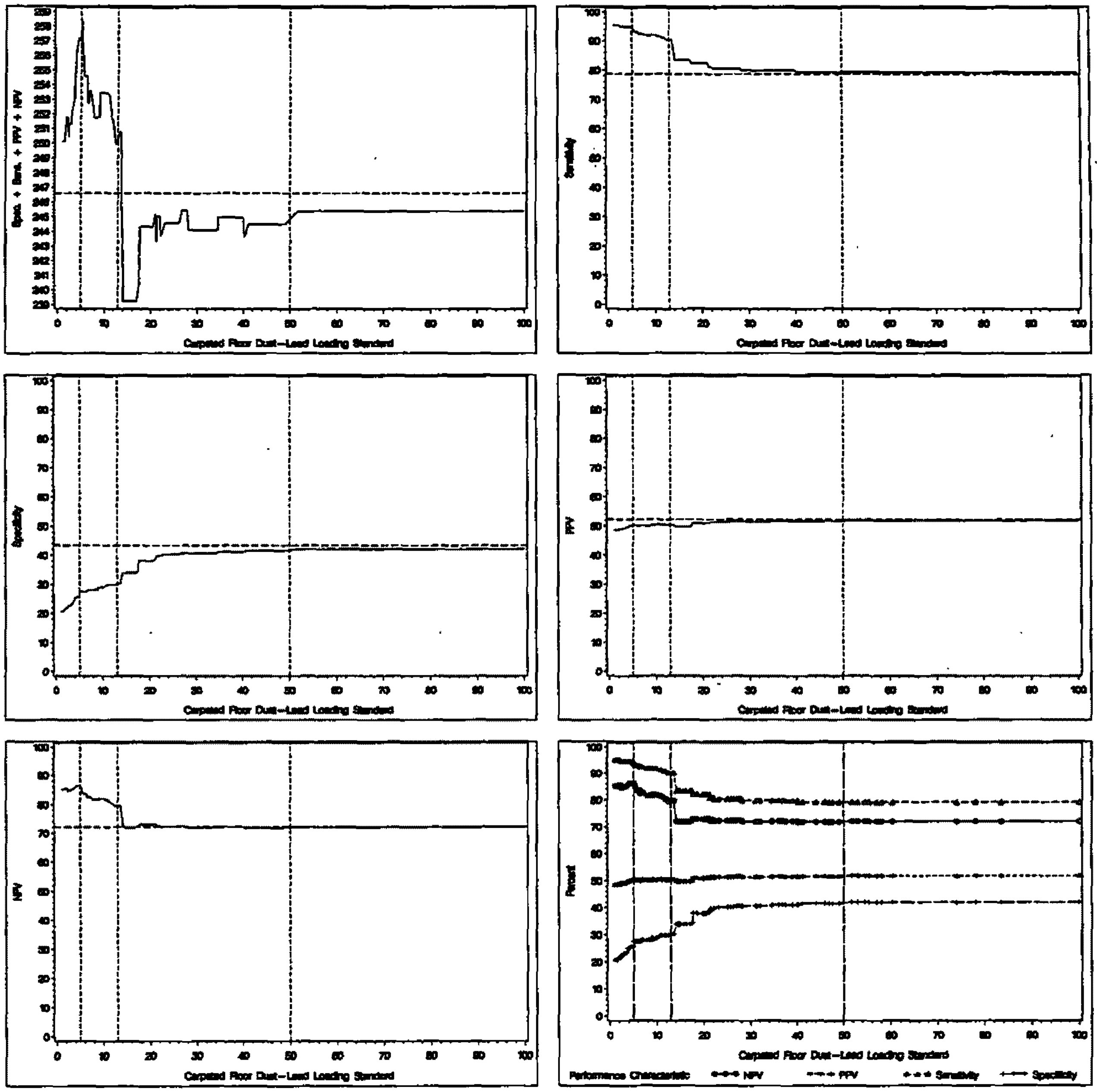

Figure 15-3. Values of the Performance Characteristics As a Function of Candidate Carpeted Floor Dust-Lead Loading Standards, Based on Analysis of the HUD Grantees Evaluation Data, Where the Set of Standards Also Includes the Uncarpeted Floor, Window Sill, and Soil Standards Proposed in the §403 Proposed Rule

(See text for the connotations of the horizontal and vertical dashed lines in these plots. The §403 proposed standards were 50 $\mu g/ft^2$ for uncarpeted floors, 250 $\mu g/ft^2$ for window sills, and 2000 ppm for soil.)

Note that in Figures I5-2 and I5-3, the sensitivity performance profile always falls above the horizontal dashed line, while the specificity performance profile always falls below the horizontal dashed line. This is because when a carpet dust-lead loading standard is added to existing standards, it cannot decrease the total number of housing units being triggered by the entire set of standards. Thus, the added standard will not decrease sensitivity, but it will not increase specificity. Equivalently, the added standard will not increase the false negative rate, but it will not decrease the false positive rate. Therefore, in evaluating the benefit of adding a carpet dust-lead loading standard, one must consider whether the improvements in some performance characteristics, such as sensitivity and the false negative rate, outweigh the losses in others, such as specificity and the false positive rate. As a result, the other two performance characteristics, positive predictive value (PPV) and negative predictive value (NPV), play more important roles in the evaluation.

In cases where only carpeted floors exist in a housing unit for dust sampling within a risk assessment, a carpet dust-lead loading standard would be needed, but not an uncarpeted floor standard. To investigate the need for such a standard in this type of scenario, the sensitivity/specificity analysis was repeated by ignoring the uncarpeted floor dust-lead loading standard. That is, the analysis considered the added benefit associated with adding a carpet dust-lead loading standard to the set of standards given by window sill dust-lead loading (250 $\mu g/ft^2$) and soil-lead concentration (2000 ppm). Figures I5-4 and I5-5 contain plots of the performance characteristic curves in the situation where the uncarpeted floor dust-lead loading standard is not used.

Some of the performance characteristics values plotted in Figures I5-2 through I5-5 are detailed within Tables I5-8 (for the Rochester study data analysis) and I5-9 (for the HUD Grantees data analysis). These tables contain calculated values of the four performance characteristics, their sum, and the percentage of housing units triggered for intervention, for the following sets of standards:

- The standards specified in the §403 proposed rule, without regard to carpet
- The standards specified in the §403 proposed rule, plus a carpet dust-lead loading standard of 50 $\mu g/ft^2$ (i.e., the same as the uncarpeted floor dust-lead loading standard)
- The standards specified in the §403 proposed rule, plus a carpet dust-lead loading standard of either 17 $\mu g/ft^2$ (for the Rochester study data), 5 $\mu g/ft^2$ (for the HUD Grantees data), or 13 $\mu g/ft^2$ (for the HUD Grantees data) (i.e., "optimal" values of the standard)
- The standards specified in the §403 proposed rule, without regard to carpeted or uncarpeted floors

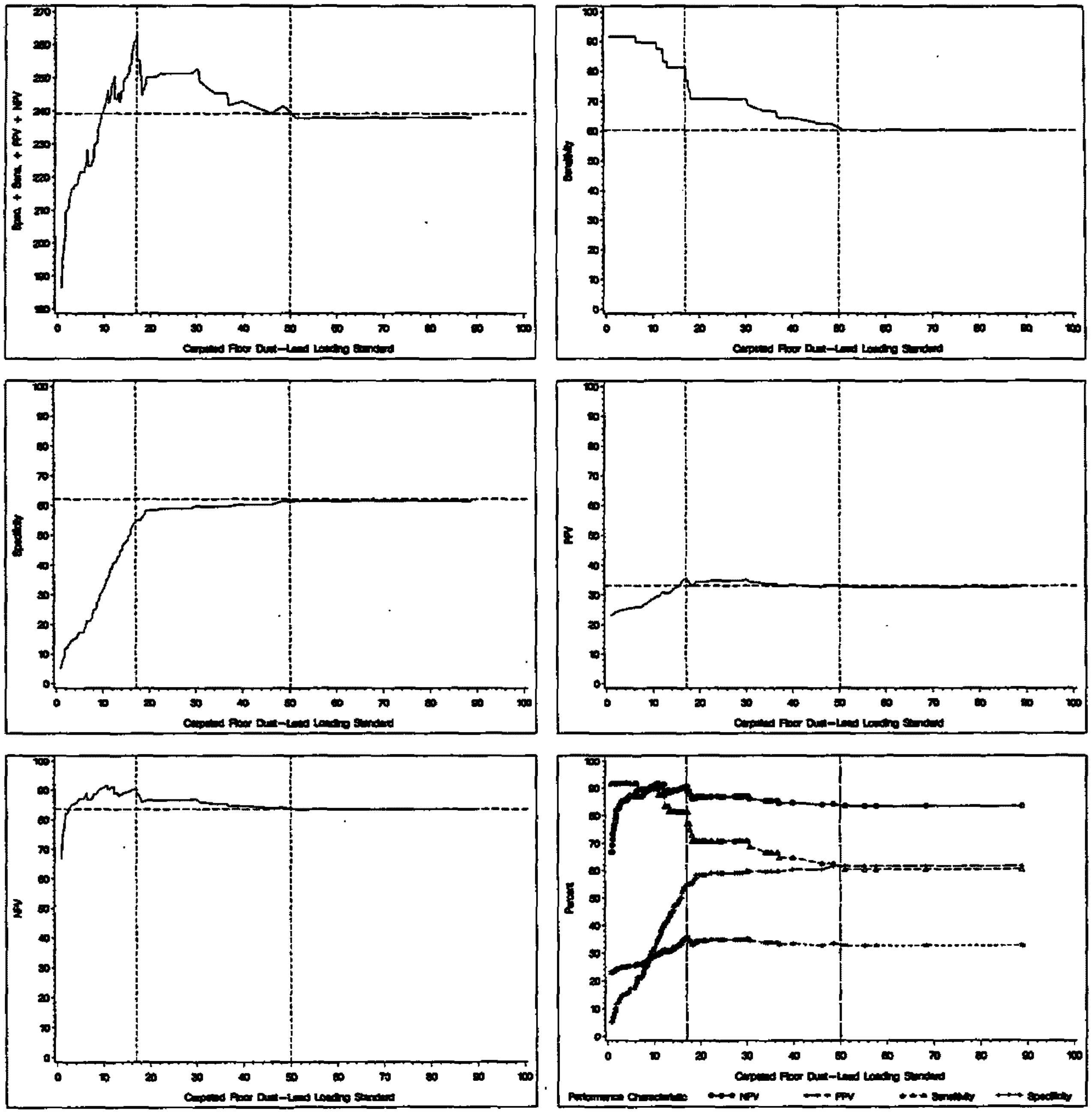

Figure I5-4. Values of the Performance Characteristics As a Function of Candidate Carpeted Floor Dust-Lead Loading Standards, Based on Analysis of the Rochester Study Data, Where the Set of Standards Also Includes the Window Sill and Soil Standards Proposed in the §403 Proposed Rule

(See text for the connotations of the horizontal and vertical dashed lines in these plots. The §403 proposed standards considered here are 250 $\mu g/ft^2$ for window sills and 2000 ppm for soil.)

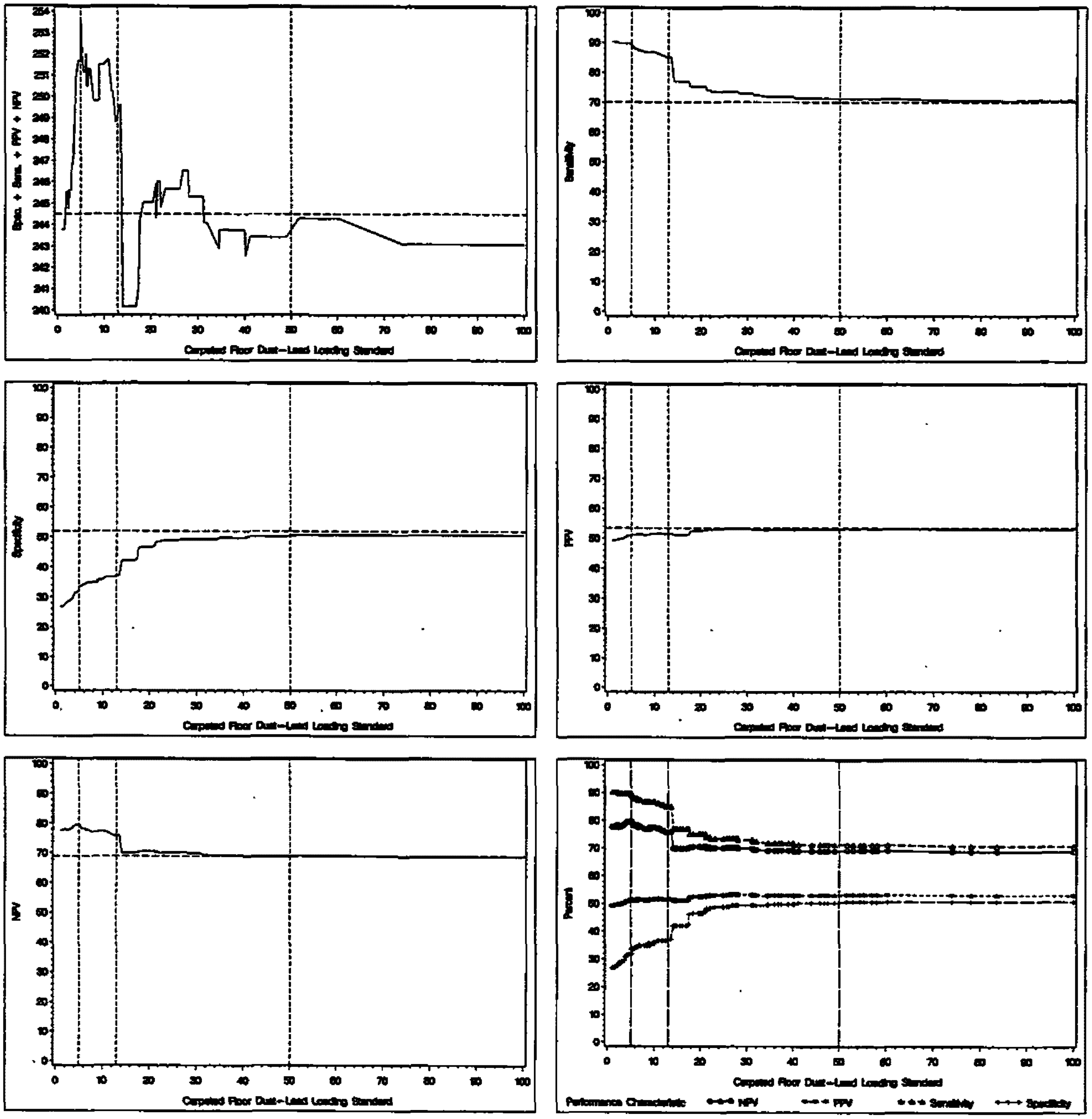

Figure I5-5. Values of the Performance Characteristics As a Function of Candidate Carpeted Floor Dust-Lead Loading Standards, Based on Analysis of the HUD Grantees Evaluation Data, Where the Set of Standards Also Includes the Window Sill and Soil Standards Proposed in the §403 Proposed Rule

(See text for the connotations of the horizontal and vertical dashed lines in these plots. The §403 proposed standards considered here are 250 $\mu g/ft^2$ for window sills and 2000 ppm for soil.)

Table I5-8. Values of the Performance Characteristics for Specified Sets of Standards, Based on Analysis of Rochester Study Data

Set of Standards	Sensitivity	Specificity	PPV	NPV	Sum of the 4 Values	% of Homes Triggered
Soil standard = 2000 ppm Sill standard = 250 $\mu g/ft^2$ Uncarpeted floor standard = 50 $\mu g/ft^2$ NO CARPET STANDARD	64.6%	60.3%	33.3%	84.7%	242.9	45.6%
Soil standard = 2000 ppm Sill standard = 250 $\mu g/ft^2$ Uncarpeted floor standard = 50 $\mu g/ft^2$ Carpeted floor standard = 50 $\mu g/ft^2$	66.7%	59.6%	33.7%	85.3%	245.3	46.6%
Soil standard = 2000 ppm Sill standard = 250 $\mu g/ft^2$ Uncarpeted floor standard = 50 $\mu g/ft^2$ Carpeted floor standard = 17 $\mu g/ft^2$	85.4%	52.6%	35.7%	92.1%	265.8	56.4%
NO UNCARPETED FLOOR STANDARD Soil standard = 2000 ppm Sill standard = 250 $\mu g/ft^2$ NO CARPET STANDARD	60.4%	62.2%	33.0%	83.6%	239.2	43.1%
NO UNCARPETED FLOOR STANDARD Soil standard = 2000 ppm Sill standard = 250 $\mu g/ft^2$ Carpeted floor standard = 50 $\mu g/ft^2$	62.5%	61.5%	33.3%	84.2%	241.5	44.1%
NO UNCARPETED FLOOR STANDARD Soil standard = 2000 ppm Sill standard = 250 $\mu g/ft^2$ Carpeted floor standard = 17 $\mu g/ft^2$	81.3%	54.5%	35.5%	90.4%	261.7	53.9%

Table I5-9. Values of the Performance Characteristics for Specified Sets of Standards, Based on Analysis of HUD Grantees Evaluation Data

Set of Standards	Sensitivity	Specificity	PPV	NPV	Sum of the 4 Values	% of Homes Triggered
Soil standard = 2000 ppm Sill standard = 250 $\mu g/ft^2$ Uncarpeted floor standard = 50 $\mu g/ft^2$ NO CARPET STANDARD	78.7%	43.4%	52.3%	72.2%	246.6	66.3%
Soil standard = 2000 ppm Sill standard = 250 $\mu g/ft^2$ Uncarpeted floor standard = 50 $\mu g/ft^2$ Carpeted floor standard = 50 $\mu g/ft^2$	79.3%	42.1%	51.9%	72.1%	245.4	67.3%
Soil standard = 2000 ppm Sill standard = 250 $\mu g/ft^2$ Uncarpeted floor standard = 50 $\mu g/ft^2$ Carpeted floor standard = 13 $\mu g/ft^2$	90.2%	30.3%	50.5%	79.8%	250.8	78.7%
Soil standard = 2000 ppm Sill standard = 250 $\mu g/ft^2$ Uncarpeted floor standard = 50 $\mu g/ft^2$ Carpeted floor standard = 5 $\mu g/ft^2$	94.8%	25.8%	50.2%	86.4%	257.2	83.3%
NO UNCARPETED FLOOR STANDARD Soil standard = 2000 ppm Sill standard = 250 $\mu g/ft^2$ NO CARPET STANDARD	70.1%	52.0%	53.5%	68.9%	244.5	57.7%
NO UNCARPETED FLOOR STANDARD Soil standard = 2000 ppm Sill standard = 250 $\mu g/ft^2$ Carpeted floor standard = 50 $\mu g/ft^2$	71.3%	50.7%	53.2%	69.1%	244.3	59.0%
NO UNCARPETED FLOOR STANDARD Soil standard = 2000 ppm Sill standard = 250 $\mu g/ft^2$ Carpeted floor standard = 13 $\mu g/ft^2$	85.1%	37.1%	51.6%	75.9%	249.7	72.7%
NO UNCARPETED FLOOR STANDARD Soil standard = 2000 ppm Sill standard = 250 $\mu g/ft^2$ Carpeted floor standard = 5 $\mu g/ft^2$	89.7%	31.7%	50.8%	79.5%	251.7	77.7%

- The standards specified in the §403 proposed rule, without regard to uncarpeted floors, plus a carpet dust-lead loading standard of 50 $\mu g/ft^2$

- The standards specified in the §403 proposed rule, without regard to uncarpeted floors, plus a carpet dust-lead loading standard of either 17 $\mu g/ft^2$ (for the Rochester study data), 5 $\mu g/ft^2$ (for the HUD Grantees data), or 13 $\mu g/ft^2$ (for the HUD Grantees data).

Tables I5-10 and I5-11 provide the 2x2 performance characteristic tables corresponding to each set of standards specified in Tables I5-8 and I5-9, respectively. In these tables, numbers in italics indicate an incorrect risk assessment (either a false positive or a false negative), while those underlined indicate a correct assessment.

The analyses presented in this subsection (for both studies) indicate that adding a carpeted floor dust-lead loading standard of 50 $\mu g/ft^2$ to the standards in the §403 proposed rule for soil, window sills and uncarpeted floors did little, if anything, to change the values of the four performance characteristics. (This can be seen, for example, in the plots within Figures I5-2 and I5-3 by noting that at a carpet dust-lead loading standard of 50 $\mu g/ft^2$, the performance curves are approximately at the horizontal dashed line.) This supports the hypothesis that the performance of the standards would not be affected by adding a carpet dust-lead loading standard equal to the proposed uncarpeted floor dust-lead loading standard (50 $\mu g/ft^2$) when both surfaces are available to sample within a housing unit. When the uncarpeted floor dust-lead loading standard is not considered (e.g., in housing units where all floor surfaces are carpeted), the same conclusion is made (see Figures I5-4 and I5-5). These findings support the hypothesis that adding a carpeted floor dust-lead standard of 50 $\mu g/ft^2$ to the currently-proposed §403 standards may not provide a sufficient level of improved performance to warrant its addition.

Other candidate carpet dust-lead loading standards that are lower than 50 $\mu g/ft^2$ appear to improve performance of the §403 proposed standards for dust and soil if they are added. These other candidate standards ranged from 5 $\mu g/ft^2$ to 17 $\mu g/ft^2$, depending on the dataset being analyzed. For analyses involving the Rochester study data (Figures I5-2 and I5-4; Tables I5-8 and I5-10), the results indicated the following:

- The candidate carpet standard resulting in the most improved performance of the proposed §403 standards (for dust and soil) was 17 $\mu g/ft^2$. Adding this standard to the proposed §403 standards increased sensitivity by 20.8 percentage points, PPV by 2.4 percentage points, and NPV by 7.4 percentage points, while it decreased specificity by 7.7 percentage points (see first and third rows of Table I5-8). Adding this standard triggered 22 additional housing units in the Rochester study, 10 of which contained children with elevated blood-lead concentrations (Table I5-10).

Table I5-10. Results of Performance Characteristics Analyses for the Sets of Standards Included in Table I5-8, Based on Analysis of Rochester Study Data

(PbB = Blood-Lead Concentration)

Standards	PbB ≥10 µg/dL?	At least one standard exceeded? No	At least one standard exceeded? Yes	Total
Soil standard = 2000 ppm Sill standard = 250 $\mu g/ft^2$ Uncarpeted floor standard = 50 $\mu g/ft^2$ NO CARPET STANDARD	Yes	17	31	48
	No	94	62	156
	Total	111	93	204
Soil standard = 2000 ppm Sill standard = 250 $\mu g/ft^2$ Uncarpeted floor standard = 50 $\mu g/ft^2$ Carpeted floor standard = 50 $\mu g/ft^2$	Yes	16	32	48
	No	93	63	156
	Total	109	95	204
Soil standard = 2000 ppm Sill standard = 250 $\mu g/ft^2$ Uncarpeted floor standard = 50 $\mu g/ft^2$ Carpeted floor standard = 17 $\mu g/ft^2$	Yes	7	41	48
	No	82	74	156
	Total	89	115	204
NO UNCARPETED FLOOR STANDARD Soil standard = 2000 ppm Sill standard = 250 $\mu g/ft^2$ NO CARPET STANDARD	Yes	19	29	48
	No	97	59	156
	Total	116	88	204
NO UNCARPETED FLOOR STANDARD Soil standard = 2000 ppm Sill standard = 250 $\mu g/ft^2$ Carpeted floor standard = 50 $\mu g/ft^2$	Yes	18	30	48
	No	96	60	156
	Total	114	90	204
NO UNCARPETED FLOOR STANDARD Soil standard = 2000 ppm Sill standard = 250 $\mu g/ft^2$ Carpeted floor standard = 17 $\mu g/ft^2$	Yes	9	39	48
	No	85	71	156
	Total	94	110	204

Table I5-11. Results of Performance Characteristics Analyses for the Sets of Standards Included in Table I5-9, Based on Analysis of HUD Grantees Evaluation Data

(PbB = Blood-Lead Concentration)

Standards			At least one standard exceeded? No	At least one standard exceeded? Yes	Total
Soil standard = 2000 ppm Sill standard = 250 $\mu g/ft^2$ Uncarpeted floor standard = 50 $\mu g/ft^2$ NO CARPET STANDARD	PbB ≥10 µg/dL?	Yes	*37*	137	174
		No	96	*125*	221
	Total		133	262	395
Soil standard = 2000 ppm Sill standard = 250 $\mu g/ft^2$ Uncarpeted floor standard = 50 $\mu g/ft^2$ Carpeted floor standard = 50 $\mu g/ft^2$	PbB ≥10 µg/dL?	Yes	*36*	138	174
		No	93	*128*	221
	Total		129	266	395
Soil standard = 2000 ppm Sill standard = 250 $\mu g/ft^2$ Uncarpeted floor standard = 50 $\mu g/ft^2$ Carpeted floor standard = 13 $\mu g/ft^2$	PbB ≥10 µg/dL?	Yes	*17*	157	174
		No	67	*154*	221
	Total		84	311	395
Soil standard = 2000 ppm Sill standard = 250 $\mu g/ft^2$ Uncarpeted floor standard = 50 $\mu g/ft^2$ Carpeted floor standard = 5 $\mu g/ft^2$	PbB ≥10 µg/dL?	Yes	*9*	165	174
		No	57	*164*	221
	Total		66	329	395
NO UNCARPETED FLOOR STANDARD Soil standard = 2000 ppm Sill standard = 250 $\mu g/ft^2$ NO CARPET STANDARD	PbB ≥10 µg/dL?	Yes	*52*	122	174
		No	115	*106*	221
	Total		167	228	395
NO UNCARPETED FLOOR STANDARD Soil standard = 2000 ppm Sill standard = 250 $\mu g/ft^2$ Carpeted floor standard = 50 $\mu g/ft^2$	PbB ≥10 µg/dL?	Yes	*50*	124	174
		No	112	*109*	221
	Total		162	233	395

Table I5-11. (cont.)

			At least one standard exceeded?		Total
			No	Yes	
NO UNCARPETED FLOOR STANDARD Soil standard = 2000 ppm Sill standard = 250 $\mu g/ft^2$ Carpeted floor standard = 13 $\mu g/ft^2$	PbB ≥10 μg/dL?	Yes	*26*	<u>148</u>	174
		No	<u>82</u>	*139*	221
	Total		108	287	395

			At least one standard exceeded?		Total
			No	Yes	
NO UNCARPETED FLOOR STANDARD Soil standard = 2000 ppm Sill standard = 250 $\mu g/ft^2$ Carpeted floor standard = 5 $\mu g/ft^2$	PbB ≥10 μg/dL?	Yes	*18*	<u>156</u>	174
		No	<u>70</u>	*151*	221
	Total		88	307	395

- When not considering the proposed uncarpeted floor standard of 50 $\mu g/ft^2$, adding a carpeted floor standard of 17 $\mu g/ft^2$ to the §403 proposed standards for soil and window sills increased sensitivity by 20.9 percentage points, PPV by 2.5 percentage points, and NPV by 6.8 percentage points, while it decreased specificity by 7.7 percentage points (see fourth and sixth rows of Table I5-8). As in the previous bullet, adding this standard triggered 22 additional housing units in the Rochester study, 10 of which contained children with elevated blood-lead concentrations (Table I5-10).

Thus, results of the analyses on Rochester study data suggest that improved performance characteristics, particularly sensitivity, are achieved with a carpeted floor standard of 17 $\mu g/ft^2$ without a large decrease in specificity. If this increased performance is considered important enough, then a carpeted floor standard (set sufficiently low enough) would be warranted for all homes.

The above results based on analysis of the HUD Grantees evaluation data (Figures I5-3 and I5-5; Tables I5-9 and I5-11) include the following:

- The candidate carpet standard resulting in the most improved performance of the proposed §403 standards (for dust and soil) was 5 $\mu g/ft^2$. Adding this standard to the proposed §403 standards increased sensitivity by 16.1 percentage points and, NPV by 14.2 percentage points, while it decreased specificity by 17.6 percentage points and PPV by 2.1 percentage points (see first and fourth rows of Table I5-9). Adding this standard triggered 67 additional housing units in the HUD Grantees evaluation, 28 of which contained children with elevated blood-lead concentrations (Table I5-11).

- The lower-right plot within Figure I5-3 indicates that a carpeted floor standard of 13 µg/ft^2 achieves some gain in overall performance without observing as large of a decrease in specificity as occurs with the candidate standard of 5 µg/ft^2. Adding this standard triggered 49 additional housing units in the HUD Grantees evaluation, 20 of which contained children with elevated blood-lead concentrations (Table I5-11). Therefore, if a large loss in specificity outweighs the gain in sensitivity and NPV that is observed with the candidate standard of 5 µg/ft^2, then the alternative standard of 13 µg/ft^2 may be of more interest.

- When not considering the proposed uncarpeted floor standard of 50 µg/ft^2, adding a carpeted floor standard of 5 µg/ft^2 to the §403 proposed standards for soil and window sills increased sensitivity by 19.6 percentage points and NPV by 10.6 percentage points, while it decreased specificity by 20.3 percentage points and PPV by 2.7 percentage points (see fifth and eighth rows of Table I5-9). Adding this standard triggered 79 additional housing units in the HUD Grantees evaluation, 34 of which contained children with elevated blood-lead concentrations (Table I5-11).

- When not considering the proposed uncarpeted floor standard of 50 µg/ft^2, adding a carpeted floor standard of 13 µg/ft^2 to the §403 proposed standards for soil and window sills had a slightly lower increase in sensitivity and NPV than adding a standard of 5 µg/ft^2, but the decrease in specificity was only 14.9 percentage points (Table I5-9).

These results indicate that improved sensitivity and NPV were achieved by adding a carpeted floor standard of 5 µg/ft^2, but a considerable decrease in specificity was also observed. Less of a loss in specificity, with only a minor loss of improvement in the other performance characteristics, was achieved when the candidate carpet standard was increased to 13 µg/ft^2. If this increased performance is considered important enough, then a carpeted floor standard (set sufficiently low enough) would be warranted for all homes.

I5.2 DETERMINING A CARPETED FLOOR DUST-LEAD LOADING STANDARD

See Section I4.2 and its subsections for details on the statistical methods associated with the results presented in this section.

I5.2.1 Comparing Average Dust-Lead Loadings Between Carpeted and Uncarpeted Floors in a Housing Unit

A total of 168 housing units in the Rochester study had wipe dust-lead loading data for both carpeted and uncarpeted floors. When considering the ratio of a housing unit's average dust-lead loading for carpeted floors versus uncarpeted floors, the geometric mean of these ratios across the 168 housing units was 0.745, indicating that the average dust-lead loading for carpeted floors was roughly 75% of the unit's average for uncarpeted floors. This geometric mean had a 95% confidence interval of (0.62, 0.90), implying that the geometric mean was significantly different from one (i.e., equal averages between carpeted and uncarpeted floors within a unit) at the 0.05 level based on a paired t-test on the log-transformed averages. Only 36% of the 168 housing units had ratios which exceeded one (i.e., had average carpeted floor dust-lead loadings that exceeded the average for uncarpeted floors).

For the Rochester study, Figure I5-6 portrays a housing unit's area-weighted average dust-lead loadings for carpeted floors versus its average for uncarpeted floors. The solid line in Figure I5-6 represents equality in the averages between the two surface types. This plot indicates that the average loadings from uncarpeted floors are generally higher than for carpeted floors.

I5.2.2 Regression Modeling Approach

Figure I5-7 presents the upper 95% prediction bounds on the curve that results from fitting model (1) of Section I4.1.1.2 to the Rochester study data to predict blood-lead concentration as a function of average floor wipe dust-lead loading. As the model was fitted separately for carpeted floor dust-lead loading data and uncarpeted floor data (with equal weight given to each housing unit), one set of prediction bounds exist for each surface type. Vertical dashed lines are included at dust-lead loadings of 17 $\mu g/ft^2$ and 50 $\mu g/ft^2$, corresponding respectively, to the "optimal" carpet dust-lead loading standard identified in the performance characteristics analysis of Section I5.1.3 on the Rochester study data and to the §403 proposed standard for uncarpeted floors.

The confidence bounds in Figure I5-7 represent predicted blood-lead concentrations for which approximately 95% of children would fall below. For example, Figure I5-7 indicates that approximately 95% of children exposed to an average carpeted dust-lead loading of 50 $\mu g/ft^2$ (the proposed uncarpeted floor standard) are expected to have blood-lead concentrations below 22.4 $\mu g/dL$. In contrast, approximately 95% of children exposed to an average uncarpeted floor dust-lead loading of 50 $\mu g/ft^2$ are expected to have blood-lead concentrations below 24.1 $\mu g/dL$. As 22.4 $\mu g/dL$ is slightly below 24.1 $\mu g/dL$, this implies that a carpet dust-lead loading standard of 50 $\mu g/ft^2$ would be at least as protective of children's blood-lead concentrations as the same standard for uncarpeted floors.

Figure I5-7 shows that the upper 95% prediction bounds for the two surfaces are very similar, generally within 2 $\mu g/dL$, with the bound for uncarpeted floors exceeding that for carpeted floors above approximately the "optimal" carpet dust-lead loading standard of 17 $\mu g/ft^2$. Approximately 95% of children exposed to either carpeted or uncarpeted floor dust-lead loadings of 17 $\mu g/ft^2$ would have blood-lead concentrations below approximately 20 $\mu g/dL$. Note that no candidate dust-lead loading standards in the ranges considered in Figure I5-7 result in 95% of children having blood-lead concentrations below 10 $\mu g/dL$.

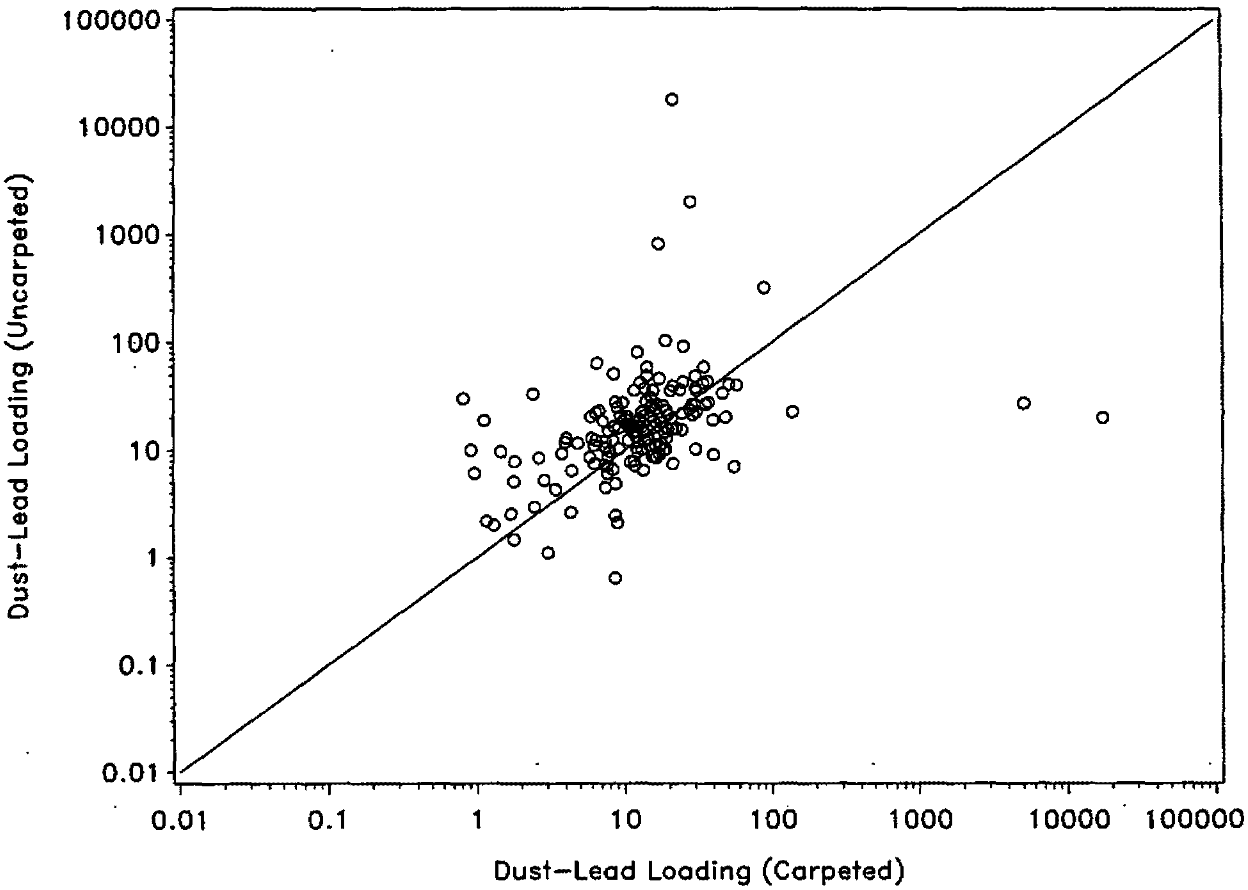

Figure I5-6. Plot of Area-Weighted Average Wipe Dust-Lead Loadings (μg/ft²) for Uncarpeted Floors Versus Carpeted Floors Within a Housing Unit in the Rochester Study

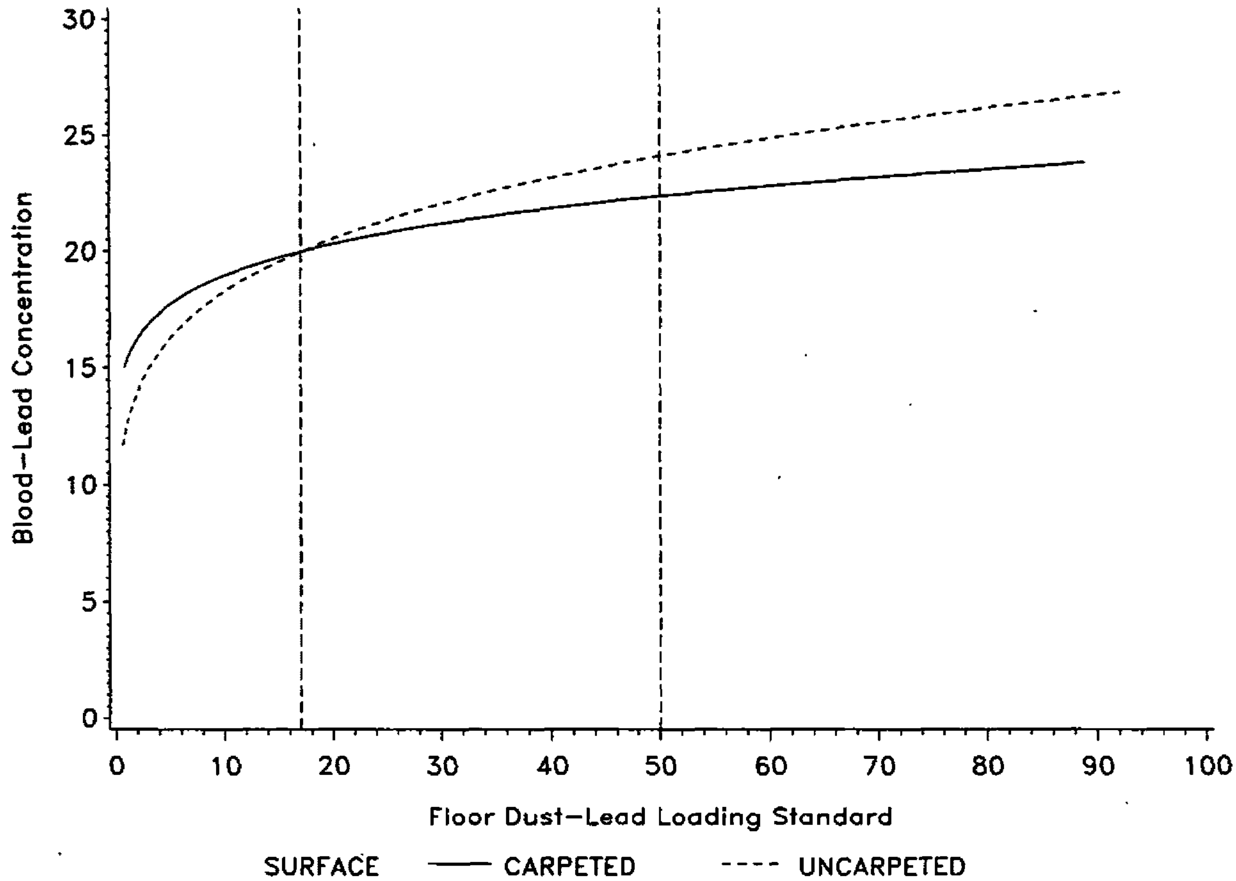

Figure I5-7. Upper 95% Prediction Bounds for Blood-Lead Concentration as a Function of Floor Dust-Lead Loading, By Surface Type, When Fitting Model (1) to Rochester Study Data

(Note: Vertical dashed lines correspond to the §403 proposed uncarpeted floor dust-lead loading standard of 50 $\mu g/ft^2$ and the "optimal" carpeted floor dust-lead loading standard of 17 $\mu g/ft^2$ from Section I5.1.3.)

I5.2.3 Performance Characteristics Analysis Approach

This section presents the results of the performance characteristics analysis whose approach was documented in Section I4.2.3. Unlike the approach taken in Section I5.1.3, where the benefits of adding a candidate carpet dust-lead loading standard to the §403 proposed standards were evaluated, this analysis calculated the four performance characteristics considering either a carpeted floor dust-lead loading standard or an uncarpeted floor dust-lead loading standard, but no other environmental-lead standard. The goal was to determine whether a particular dust-lead loading standard performed at least as well for carpeted floors as for uncarpeted floors.

Figure I5-8 presents the results of this performance characteristics analysis performed on the Rochester study data. One plot exists in Figure I5-8 for each of the four performance characteristics and for the sum of these four characteristics. The vertical axes of these plots identify the performance characteristic being plotted. Solid-line performance curves correspond to carpeted floors, and dashed-line performance curves correspond to uncarpeted floors. Like in Figure I5-7, vertical dashed lines exist in each plot at 50 and 17 $\mu g/ft^2$.

The plots within Figure I5-8 indicate the following:

- The proposed uncarpeted floor standard of 50 $\mu g/ft^2$ results in a considerably lower value for the sum of the four performance characteristics when the standard is assumed to be for carpeted floors rather than for uncarpeted floors. In contrast, candidate standards from 15 to 20 $\mu g/ft^2$ result in considerably higher values for this sum when the standard is assumed to be for carpeted floors. (Note that this result tends to agree with the results in Section I5.1.3.)

- To achieve sensitivity at the level observed for the §403 proposed standard for uncarpeted floors (50 $\mu g/ft^2$), the carpeted floor dust-lead loading standard must be below approximately 33 $\mu g/ft^2$.

- At a standard of 50 $\mu g/ft^2$, PPV is lower if the standard is for carpeted floors than if it is for uncarpeted floors. Among the candidate carpeted floor dust-lead loading standards, PPV is maximized at 30 $\mu g/ft^2$; this maximum is approximately equal to the PPV for the §403 proposed standard for uncarpeted floors of 50 $\mu g/ft^2$.

- The performance curves for NPV differ little, if any, between carpeted and uncarpeted surfaces across the range of candidate standards.

The conclusion of this performance characteristics analysis is that, for carpeted floors, a standard of 30 $\mu g/ft^2$ may be needed to achieve a level of protection equal to that of the §403 proposed standard of 50 $\mu g/ft^2$ for uncarpeted floors. Furthermore, a standard of 17 $\mu g/ft^2$ continues to be among the better performers when the total of the four performance characteristics is considered as a criterion.

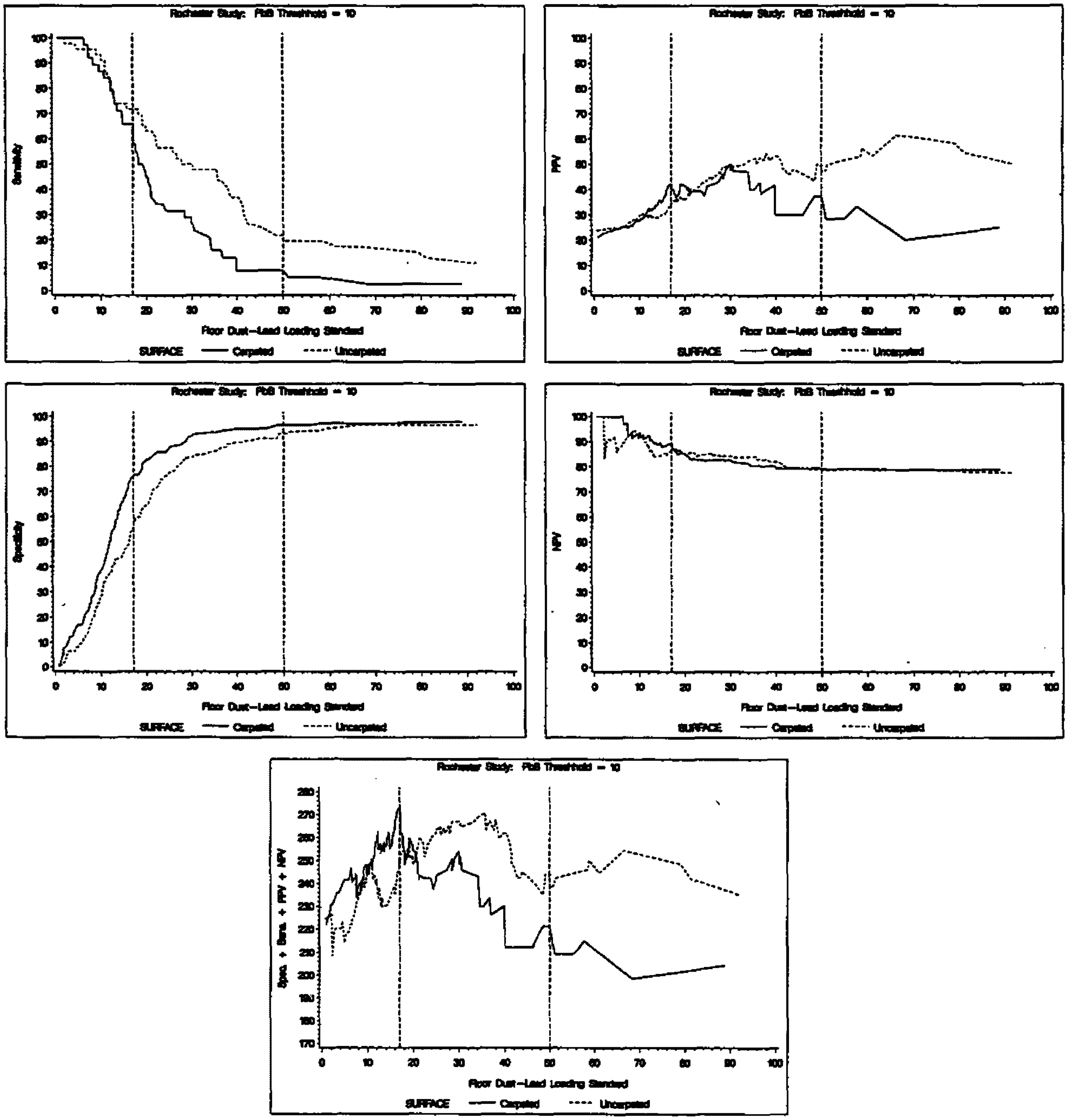

Figure I5-8. Values of the Four Performance Characteristics Versus Floor Dust-Lead Loading Standard By Surface Type, Where No Other Standards Were Considered, Based on Analyses Performed on Rochester Study Data

(Note: Vertical dashed lines correspond to the §403 proposed uncarpeted floor dust-lead loading standard of 50 $\mu g/ft^2$ and the "optimal" carpeted floor dust-lead loading standard of 17 $\mu g/ft^2$ from Section I5.1.3.)

I5.3 DETERMINING AN APPROPRIATE METHOD FOR SAMPLING CARPET DUST

See Section I4.3 and its subsections for details on the statistical methods associated with the results presented in this section.

Besides wipe sampling, the Rochester study employed BRM and DVM vacuum sampling on carpeted and uncarpeted floors, while the HUD Grantees evaluation included a few measurements on carpeted floor dust samples collected using the DVM. These vacuum sampling methods, however, require specialized equipment and more training to use effectively. In addition, vacuum sampling is more complex and costly relative to any added benefit it may provide (Section 403 Dialogue Process minutes, December 14, 1995). Therefore, in discussions regarding the §403 risk analysis, wipe sampling was supported as dust collection method in which the dust-lead standards would be expressed.

Sections I5.3.1 through I5.3.3 contain the results of analyses to compare dust-lead loadings between the different dust sampling methods employed in the Rochester study and HUD Grantees evaluation for carpeted and uncarpeted floors. Also compared in these analyses were dust-lead concentrations measured within dust samples obtained using vacuum techniques (BRM, DVM). The results in this section are supported by the additional data summaries found in Appendix I2. The main findings of these results were as follows:

- Blood-lead concentration correlated more highly with dust-lead loading than with dust-lead concentration on both carpeted and uncarpeted surfaces.

- Each dust collection method resulted in measured dust-lead loadings that were statistically significant predictors of blood-lead concentration. There was not strong evidence to favor any particular method based on predictive ability.

- Dust-lead loadings on either surface were significantly positively correlated between dust collection methods. Additionally, one may predict wipe loadings based on BRM- and DVM-measured loadings using the regression results in Section I5.3.3. Thus, exclusive use of wipe sampling for floor-dust captured some of the information that would be available from use of vacuum sampling.

- On carpeted floors in these two studies, vacuum sampling methods collected samples having significantly different loading measurements compared to wipe sampling (see Tables I2-1 and I2-6a of Appendix I2, and Section I5.3.3). As a consequence, a standard designed for wipe sampling would not apply to vacuum-sampled floor dust-lead, and vice versa.

- As the uncarpeted floor dust-lead loading standard assumes wipe sampling, and dust-lead loadings under each of the three dust collection methods have significant correlations with blood-lead concentration for both carpeted and uncarpeted floors (as seen in Section I5.3.1), these results imply that it is reasonable to develop a carpeted floor dust-lead standard for the wipe sampling method. As this standard would not apply to vacuum sampled dust-lead loadings, measurements taken with vacuum sampling could not be used in risk assessment via the §403 rule.

I5.3.1 Investigating the Association Between Floor Dust-Lead Levels and Blood-Lead Concentration for Different Sampling Methods

This subsection presents, for both carpeted and uncarpeted floors and for each of the three dust collection methods, analyses of the Rochester study and HUD Grantees evaluation data to investigate the bivariate relationships between children's blood-lead concentration and area-weighted household average floor dust-lead loading. Furthermore, using the Rochester study data, this subsection also investigates the relationships between children's blood-lead concentration and mass-weighted average floor dust-lead concentration, for each of the two vacuum dust collection methods and for carpeted and uncarpeted floors separately.

Rochester Study

Figure I5-9 contains six plots, each depicting blood-lead concentration versus household average floor dust-lead loading for a given combination of dust collection method and floor surface type (carpeted or uncarpeted), as measured in the Rochester study. Figure I5-10 contains four plots, each presenting blood-lead concentration versus household average floor dust-lead concentration for each combination of the two vacuum collection methods and the two floor surface types. Each point within the plots in Figures I5-9 and I5-10 represents a single housing unit surveyed in the Rochester study.

As all plots in Figure I5-9 cover the same ranges along their vertical and horizontal axes, it is possible to see, for example, how average dust-lead loadings are generally higher when samples are collected by the BRM than by the DVM, especially for carpeted surfaces. The plots in Figure I5-9 show some positive correlation between dust-lead loadings and blood-lead concentration, but the level of variability in these relationships is high under all dust collection methods. Little, if any, correlation is observed between dust-lead concentration and blood-lead concentration (Figure I5-10) for either vacuum method or floor surface type.

For each plot in Figures I5-9 and I5-10, a Pearson correlation coefficient was calculated on the data in the plot to quantify the extent of linear relationship between log-transformed blood-lead concentration and log-transformed average floor dust-lead level, with each average weighted by the proportion of total floor sample area in the unit represented by the given surface type. The correlation coefficients for a particular surface type (carpet, non-carpet) are presented in Table I5-12.

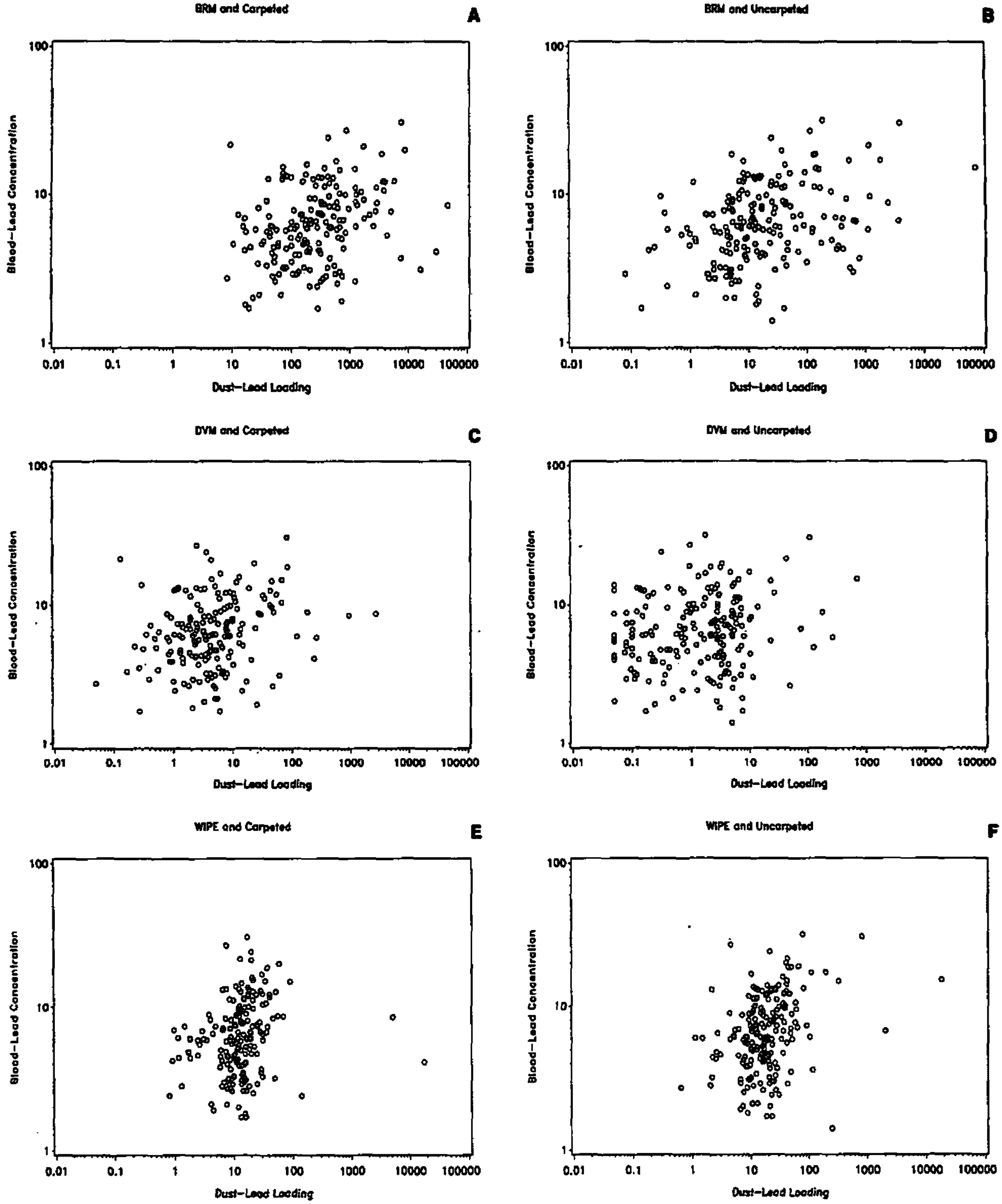

Figure I5-9. Plots of Blood-Lead Concentration (µg/dL) Versus Weighted Average Floor Dust-Lead Loading (µg/ft²) in the Rochester Study, by Dust Collection Method and Floor Surface

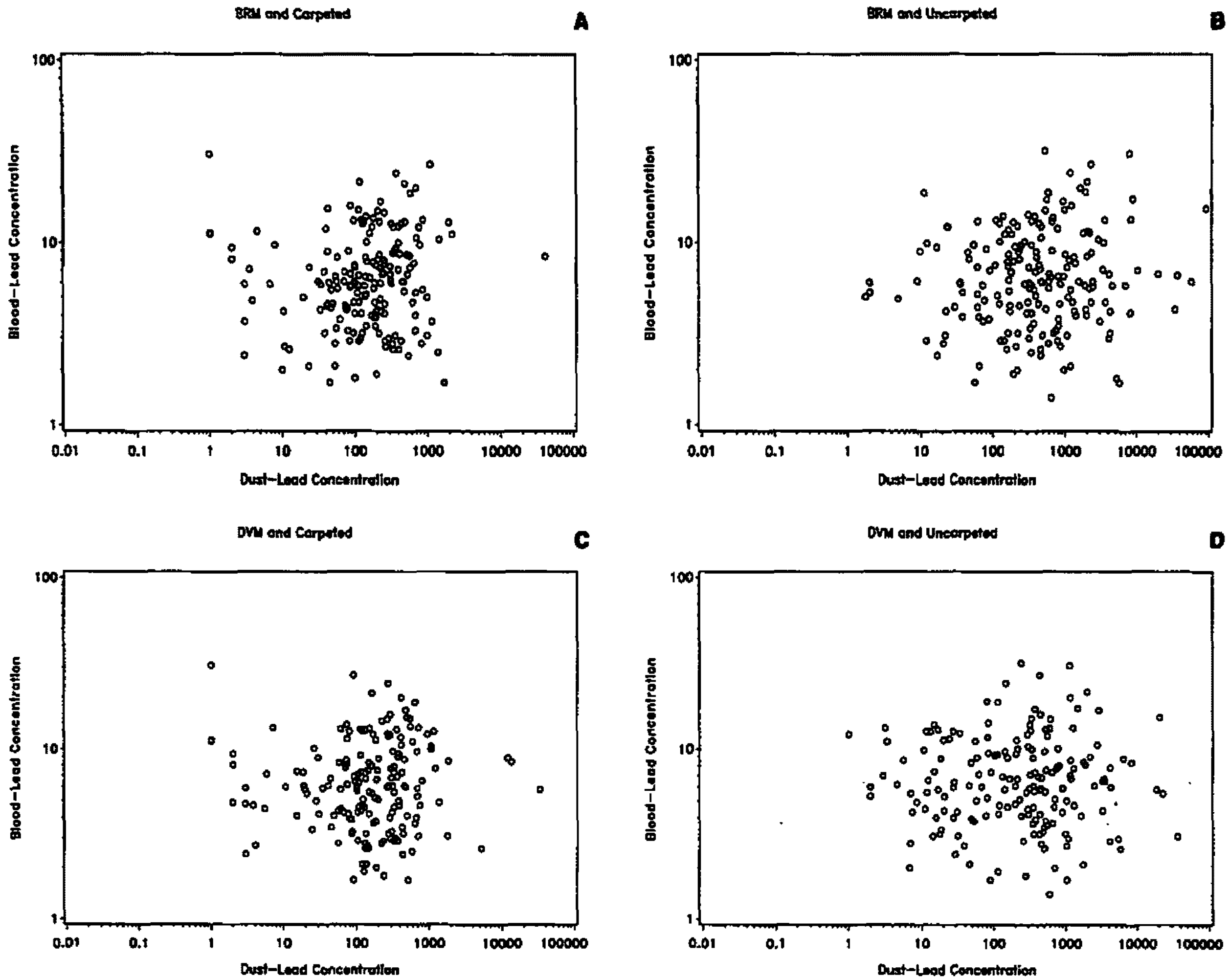

Figure I5-10. Plots of Blood-Lead Concentration (µg/dL) Versus Weighted Average Floor Dust-Lead Concentration (µg/g) in the Rochester Study, by Dust Collection Method and Floor Surface

Table I5-12. Pearson Correlation Coefficients of Log-Transformed Average Dust-Lead Levels with Log-Transformed Blood-Lead Concentration, as Measured in the Rochester Study, for Differing Dust Collection Methods and Measurement Types

Floor Dust-Lead Variable[1]	Correlation with Blood-Lead Concentration					
	BRM		DVM		Wipe	
	Carpeted Floors	Uncarpeted Floors	Carpeted Floors	Uncarpeted Floors	Carpeted Floors	Uncarpeted Floors
Area-weighted average dust-lead loading	0.339** (179)	0.364** (191)	0.239** (181)	0.152* (194)	0.190* (179)	0.313** (193)
Mass-weighted average dust-lead concentration	0.100 (178)	0.086 (189)	0.046 (177)	-0.037 (177)		

[1] Correlation coefficients are calculated on unit-wide area-weighted average dust-lead loadings or mass-weighted dust-lead concentrations, where averages are taken across all samples in a housing unit of the given surface type (carpet or non-carpet). The average for a given housing unit is weighted by the proportion of total floor sample area in the unit represented by carpeted (uncarpeted) surfaces in calculating the correlation coefficient for carpeted (uncarpeted) floors.

** Significant at the 0.01 level.
* Significant at the 0.05 level.

The results in Table I5-12 indicate the following:

- None of the correlations between blood-lead concentration and average dust-lead <u>concentration</u> were significant at the 0.05 level for either the BRM or DVM or for either carpeted or uncarpeted surfaces (see the last row of the table).

- Significant correlation was observed at the 0.05 level between blood-lead concentration and average dust-lead <u>loading</u> for each dust collection method when sampling from either carpeted or uncarpeted floors. Among carpeted floor data, the correlation coefficients between dust-lead loading and blood-lead concentration ranged from 0.190 under wipe methods to 0.339 under the BRM, while for uncarpeted floor data, these correlation coefficients ranged from 0.152 for the DVM to 0.364 for the BRM. Only for the DVM was the correlation coefficient larger for carpeted surfaces than for uncarpeted surfaces.

These results differ slightly from correlation coefficients reported in the Rochester study report (the Rochester School of Medicine and NCLSH, 1995), primarily due to the form of the dust-lead parameter (this analysis used a log-transformed weighted arithmetic average of untransformed data, while the Rochester study report used an untransformed, unweighted average of log-transformed data). However, the results in Table I5-12 agree with the findings of other studies (see Section I5.1.2 of USEPA, 1997a) that blood-lead concentration correlates more highly with dust-lead loading than dust-lead concentration; this result was observed for both carpeted and uncarpeted surfaces.

To further investigate the statistical nature of the bivariate relationships represented in Table I5-12, the regression model (1) of Section I4.1.1.1 was fitted to Rochester study data for each of these ten pairs of parameters. Table I5-13 presents the estimated slope and intercept terms for each model fit, along with the standard errors of each estimate. Significant slope estimates imply that the predictor variable is significantly associated with blood-lead concentration.

Results from Table I5-13 are as follows:

- For all but one of the model fits, the slope estimate was positive, implying increased blood-lead concentrations associated with increased values of the dust-lead predictor variable. (The negative estimate associated with the remaining model fit was not significantly different from zero.)

- At the 0.05 level, dust-lead loadings were statistically significant predictors of blood-lead concentration under each dust collection method and for both carpeted and uncarpeted floors, while dust-lead concentrations were not significant predictors.

- All three dust collection methods, when used to measure dust-lead loading, were significant predictors of blood-lead concentration. No strong evidence was uncovered to favor any one over the others based on predictive ability from this analysis.

- Dust-lead levels from carpeted floors did not appear to predict blood-lead concentration any more or less accurately than did dust-lead levels from uncarpeted floors.

<u>HUD Grantees Program Evaluation</u>

Floor dust samples were collected by either wipe or DVM vacuum methods in the HUD Grantees evaluation, with the DVM method used only to collect a few carpet-dust samples. Figure I5-11 graphically portrays the three sets of relationships between blood-lead concentration and average floor dust-lead loading (carpet dust-lead loadings under DVM and under wipe, and uncarpeted floor wipe dust-lead loadings). Each point within the plots represents a single housing unit. While each plot in Figure I5-11 tends to show a positive relationship between the two endpoints, considerable variability associated with this relationship is present.

Pearson correlation coefficients were calculated on the data within each plot in Figure I5-11 to quantify the extend of linear relationship between the log-transformed blood-lead

Table I5-13. Estimates of Intercept and Slope Parameters (and Their Standard Errors) Associated With Regression Models Fitted to Rochester Study Data That Predict Blood-Lead Concentration Based on Average Floor Dust-Lead Level, for Different Surface Types and Dust Collection Methods

Floor Surface Type	Dust-Lead Endpoint (PbD)	Estimates (Standard Errors)		
		Intercept (μ)	Baseline (e^{μ}; μg/dL)	Slope (α)
Carpeted surfaces	BRM Loading	1.08 (0.16)	2.95	0.129** (0.027)
	DVM Loading	1.66 (0.06)	5.25	0.094** (0.029)
	Wipe Loading	1.53 (0.11)	4.61	0.103* (0.040)
	BRM Concentration	1.59 (0.16)	4.92	0.042 (0.031)
	DVM Concentration	1.71 (0.14)	5.55	0.016 (0.027)
Uncarpeted surfaces	BRM Loading	1.55 (0.08)	4.72	0.111** (0.021)
	DVM Loading	1.88 (0.05)	6.56	0.054* (0.025)
	Wipe Loading	1.39 (0.12)	4.03	0.174** (0.038)
	BRM Concentration	1.73 (0.16)	5.62	0.030 (0.025)
	DVM Concentration	1.98 (0.14)	7.24	-0.012 (0.024)

The regression model takes the form $\log(PbB_i) = \mu + \alpha(\log(PbD_i)) + \epsilon_i$, or equivalently, $PbB_i = \exp(\mu) \times (PbD_i)^{\alpha} \times \exp(\epsilon_i)$, where PbB is the blood-lead concentration for the child in the ith housing unit, ϵ_i refers to the random error associated with the model-based blood-lead concentration for the ith unit, and remaining notation is specified in the column headings. For a specific surface type, results for the ith unit are weighted by the proportion of total area represented by that surface type.

* Significantly different from zero at the 0.05 level.
** Significantly different from zero at the 0.01 level.

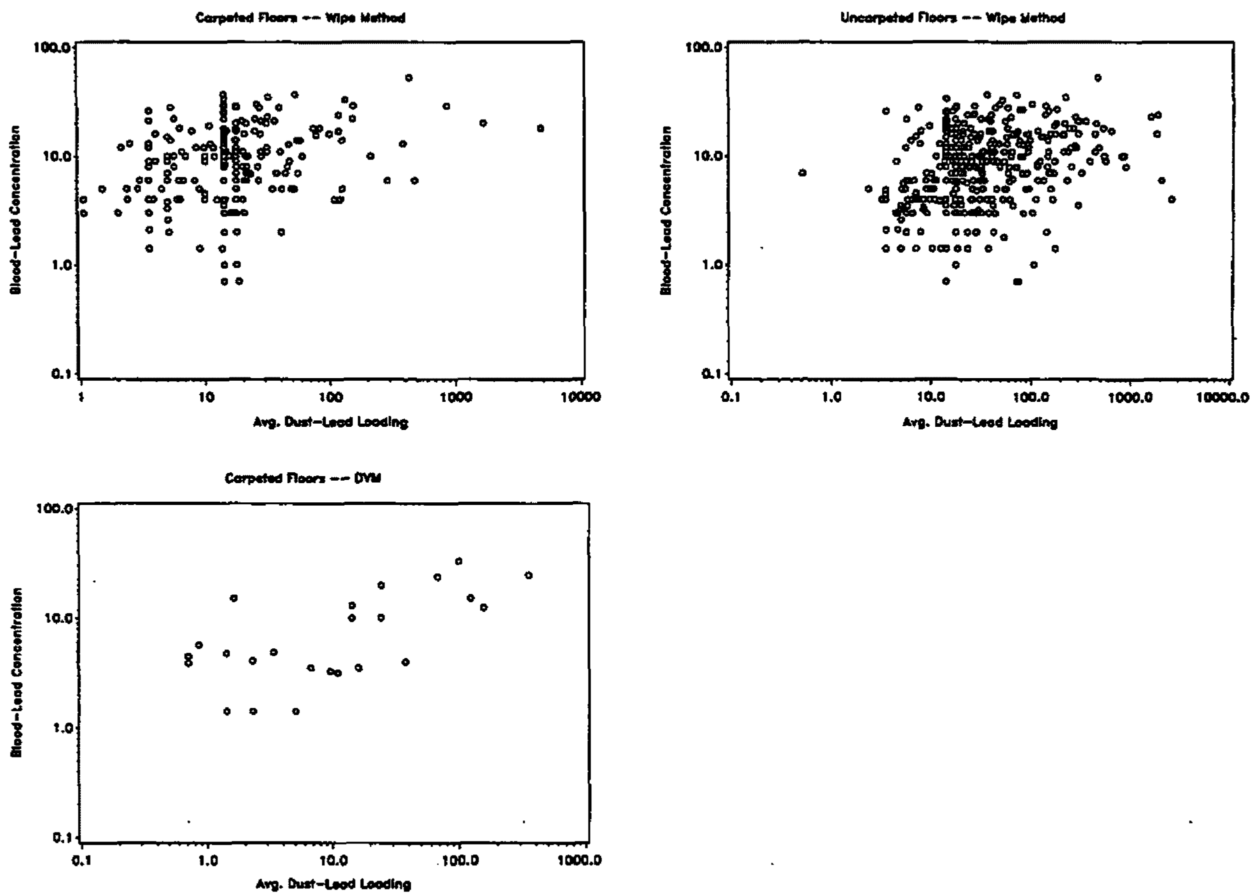

Figure I5-11. Plots of Blood-Lead Concentration (μg/dL) Versus Area-Weighted Average Floor Dust-Lead Loading (μg/ft²), by Dust Collection Method and Floor Surface Type, for Housing Units in the HUD Grantees Program Evaluation

concentration and log-transformed average floor dust-lead loading. These correlation coefficients are presented in Table I5-14. As was seen with the correlation coefficients calculated on the Rochester study data (Table I5-12), all three correlation coefficients in Table I5-14 were positive and significant at the 0.05 level, implying that increased blood-lead concentration was associated with increased dust-lead loading for each floor surface type and dust collection method.

To further investigate the statistical nature of the relationships between the blood-lead concentration and the dust-lead loadings documented in Table I5-14, and to take into account grantee effects on blood-lead concentration, regression model (1) in Section I4.1.1.1 was fitted to the data portrayed in Figure I5-11 each of the three pairs of parameters. Table I5-15 contains the estimated slope and its standard error for each model fitting. In particular, this table shows the following:

Table I5-14. Pearson Correlation Coefficients of Log-Transformed Blood-Lead Concentration and Log-Transformed Average Dust-Lead Loading as Measured in the HUD Grantees Program Evaluation, According to Dust Collection Method and Floor Surface Type

Dust Collection Method	Pearson Correlation Coefficients[1] (Number of Housing Units)	
	Carpeted Floors	Uncarpeted Floors
DVM	0.640** (24)	(Not collected)
Wipe	0.308** (226)	0.335** (390)

[1] Area-weighted average dust-lead loadings are taken across all samples in a housing unit of the given dust collection method and surface type (carpeted or uncarpeted). The average for a given housing unit is weighted by the proportion of total sample area in the unit represented by carpeted (uncarpeted) floors for calculating the correlation coefficient with carpeted (uncarpeted) floors for each dust collection method.

** Significantly different from zero at the 0.01 level.

Table I5-15. Estimates of Slope Parameters (and Their Standard Errors) Associated With Regression Models Fitted to Data from the HUD Grantees Program Evaluation That Predict Blood-Lead Concentration Based on Average Floor Dust-Lead Loading, For Different Surface Types and Dust Collection Methods

Dust Collection Method	Surface Type	# of Units	Slope (α)[1] (Std. Error)
Wipe	Carpeted Floor	226	0.160** (0.048)
	Uncarpeted Floor	390	0.117** (0.030)
DVM	Carpeted Floor	24	0.279** (0.074)

[1] The regression model takes the form $\log(PbB_{ij}) = \gamma_j + \alpha * \log(PbD_{ij}) + \epsilon_{ij}$, where PbB_{ij} represents the blood-lead concentration for the selected child in the ith housing unit within the jth grantee, PbD_{ij} corresponds to the observed average floor dust-lead loading for the ith housing unit within the jth grantee (for the given dust collection method and surface type), and α and γ_j are parameters representing the slope of the model and the intercept for the jth grantee, respectively. The residual error left unexplained by the model is denoted by ϵ_{ij}. Observations entering into the model are weighted by the proportion of total sample area in the unit represented by carpeted (or uncarpeted) floors for each dust collection method.

* Significantly different from zero at the 0.05 level.
** Significantly different from zero at the 0.01 level.

- The slope for each model fit was statistically significantly positive (at the 0.01 level), indicating that average dust-lead loadings were significantly associated with blood-lead concentration and that high blood-lead concentrations were associated with high dust-lead loadings. (Similar results were observed in Table I5-13 when the Rochester data were analyzed, but significance was not always at the 0.01 level.)

- As in the Rochester study data analysis, there was not strong evidence to favor DVM over wipe sampling based on predictive ability in this analysis. However, there were so few DVM measurements taken in the HUD Grantees evaluation that it was difficult to make any conclusions from the available DVM measurement data.

- As was seen in analysis of the Rochester study data, dust-lead levels from carpeted floors were not found to predict blood-lead concentration any more or less accurately than do dust-lead levels from uncarpeted floors.

I5.3.2 Determining the Relationship of Average Dust-Lead Levels Between Sampling Methods

This analysis of Rochester study data, documented in Section I4.3.2, investigated the bivariate relationship between the following pairs of dust-lead measurements, with each comparison done separately for carpeted and uncarpeted floors:

- Average BRM dust-lead loading versus average DVM dust-lead loading
- Average BRM dust-lead concentration versus average DVM dust-lead concentration
- Average BRM dust-lead loading versus average wipe dust-lead loading
- Average DVM dust-lead loading versus average wipe dust-lead loading
- Average BRM dust-lead loading versus average BRM dust-lead concentration
- Average DVM dust-lead loading versus average DVM dust-lead concentration

Data for these six pairs of parameters are plotted within Figures I5-12 through I5-14, with separate plots generated for data from carpeted floors and from uncarpeted floors. Four plots of BRM versus DVM dust-lead levels (loadings and concentrations) are found in Figure I5-12, four plots of wipe versus vacuum dust-lead loadings are found in Figure I5-13, and four plots of dust-lead concentrations versus loadings for vacuum methods are found in Figure I5-14. Each plotted point corresponds to average results for a single housing unit in the Rochester study. If dust-lead levels agreed perfectly among samples of different dust collection methods within a unit, the plotted points in Figures I5-12 and I5-13 would fall along the solid line representing equality in these plots.

The plots in Figures I5-12 through I5-14 indicate the following:

- For both uncarpeted and carpeted surfaces in a housing unit, dust-lead loadings were generally lower for the DVM than for the BRM (plots A and B of Figure I5-12) or under the wipe method (plots C and D of Figure I5-13).

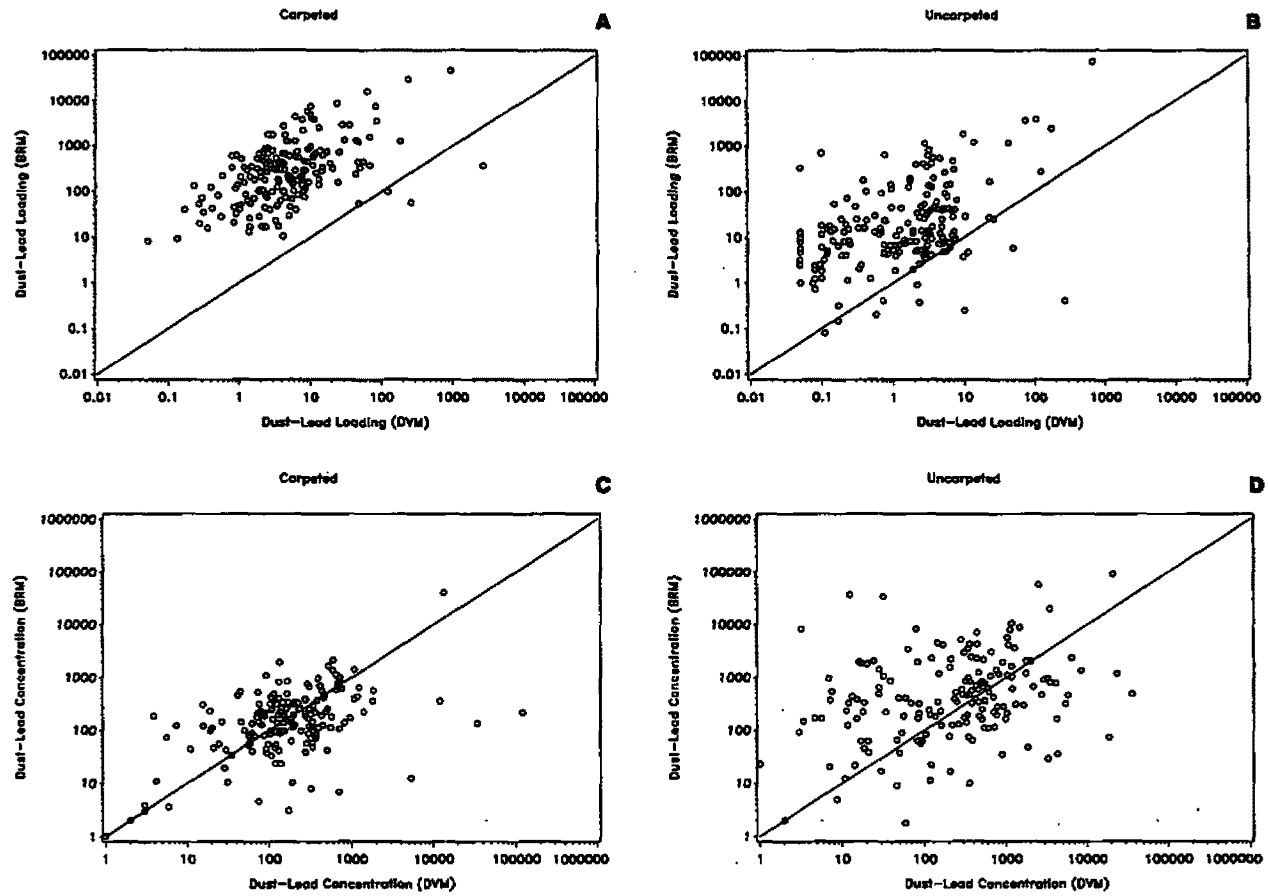

Figure I5-12. Plots of Weighted Average Dust-Lead Loadings ($\mu g/ft^2$) and Concentrations ($\mu g/g$) for BRM Dust Samples Versus DVM Dust Samples in the Rochester Study, by Floor Surface Type

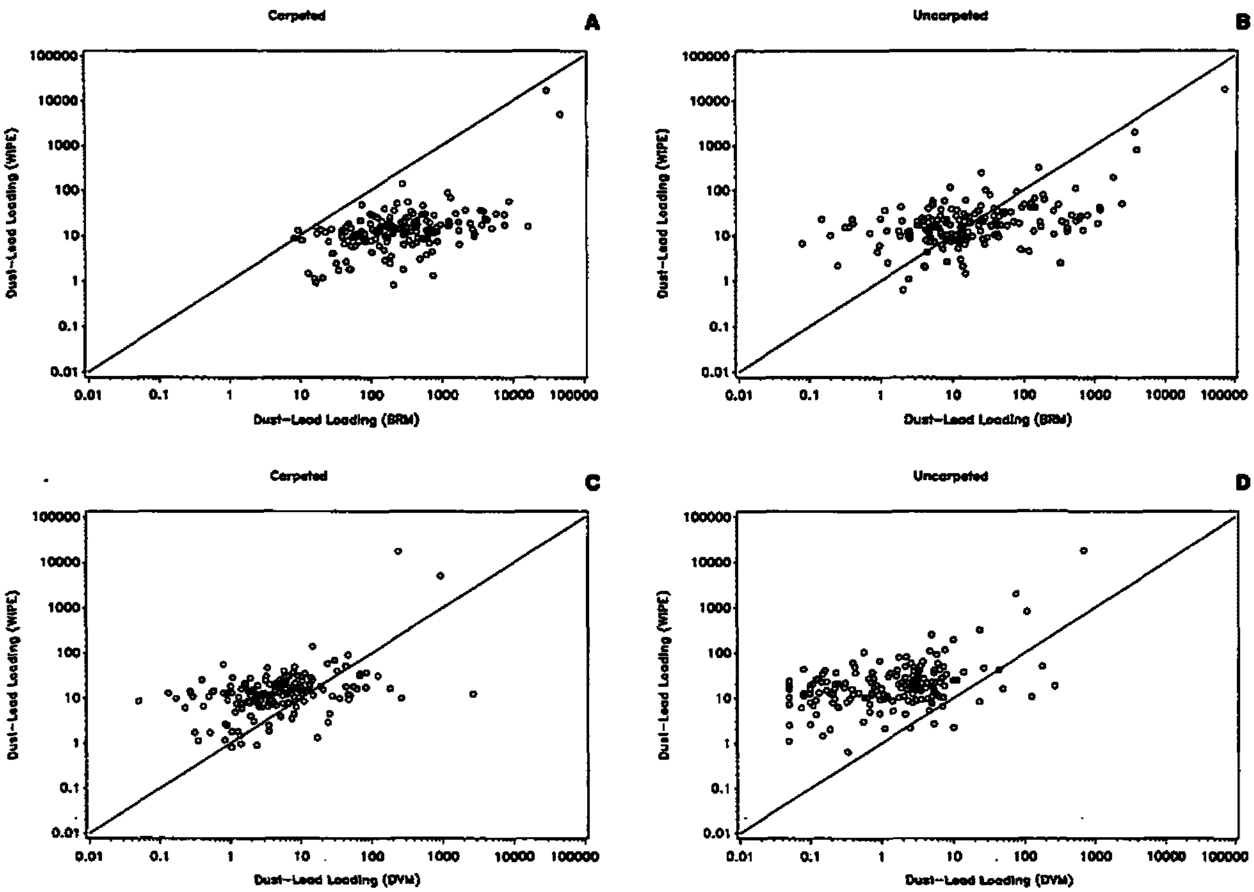

Figure I5-13. Plots of Weighted Average Dust-Lead Loadings ($\mu g/ft^2$) for Wipe Dust Samples Versus BRM and DVM Dust Samples in the Rochester Study, by Floor Surface Type

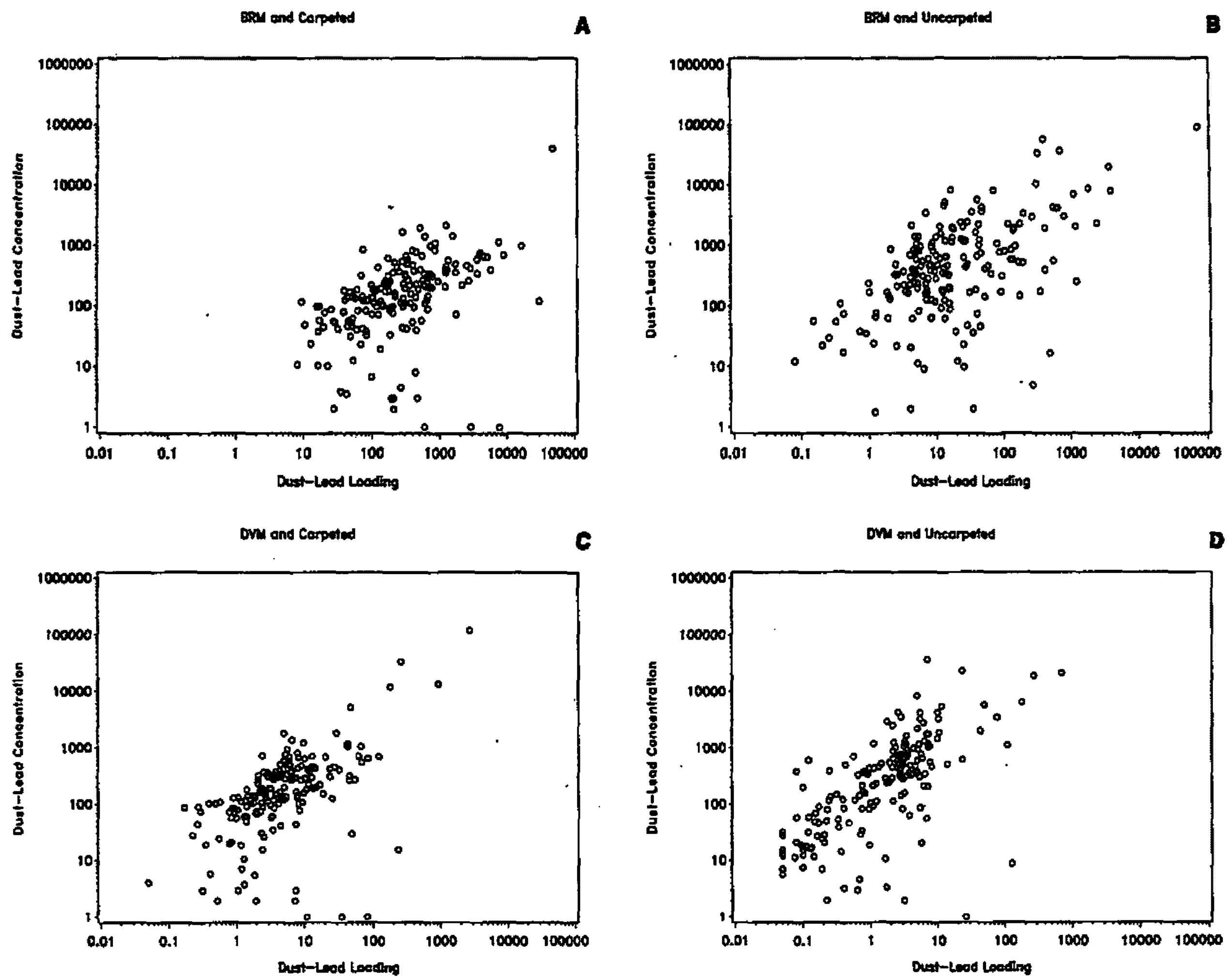

Figure I5-14. Plots of Weighted Average Dust-Lead Concentrations (µg/g) Versus Average Dust-Lead Loadings (µg/ft²) for BRM and DVM Dust Samples in the Rochester Study, by Floor Surface Type

- In Figure I5-13, larger dust-lead loadings for the BRM were observed relative to the wipe method for carpeted surfaces (plot A) but not for uncarpeted surfaces (plot B).

- In general, wipe results were less variable than were the BRM and DVM results for both carpeted and uncarpeted surfaces (Figure I5-13).

The plots in Figure I5-14 show generally positive relationships between dust-lead concentrations and dust-lead loadings among the (vacuum) dust collection methods and surface types.

For carpeted and uncarpeted surfaces separately in the Rochester study, Pearson correlation coefficients were calculated to observe the extent of a linear relationship in the log-transformed area-weighted average dust-lead loadings (and mass-weighted average dust-lead concentrations) between different dust collection methods, as well as the extent of a linear relationship between log-transformed dust-lead loadings and log-transformed dust-lead concentrations for each dust collection method. These correlation coefficients are presented in Table I5-16. Note that in calculating a correlation coefficient on data associated with carpeted floors, each data point was weighted by the proportion of floor sample area in the housing unit represented by carpeted surfaces for the dust collection method(s) being considered, while data associated with uncarpeted floors were weighted by the proportion of floor sample area represented by uncarpeted surfaces.

Table I5-16. Pearson Correlation Coefficients of Log-Transformed Dust-Lead Levels Measured in the Rochester Study, for Differing Dust Collection Methods or Measurement Types

Pair of Parameters Considered in the Correlation	Type of Data Considered in the Correlation	Pearson Correlation Coefficients[1] (Number of Housing Units)	
		Carpeted Surfaces	Uncarpeted Surfaces
ρ(BRM, DVM)	Dust-Lead Loading	0.545** (179)	0.493** (191)
	Dust-Lead Concentration	0.549** (175)	0.389** (173)
ρ(BRM, Wipe)	Dust-Lead Loading	0.520** (177)	0.523** (191)
ρ(DVM, Wipe)	Dust-Lead Loading	0.456** (179)	0.463** (193)
ρ(dust-lead loading, dust-lead concentration)	BRM	0.510** (178)	0.551** (189)
	DVM	0.601** (177)	0.623** (177)

[1] Correlation coefficients are calculated on unit-wide area-weighted average dust-lead loadings or mass-weighted dust-lead concentrations, where averages are taken across all samples in a housing unit of the given surface type (carpet or non-carpet). In these calculations, the average for a given housing unit is weighted by the proportion of total sample area in the unit represented by carpeted (uncarpeted) surfaces in calculating the correlation coefficient for carpeted (uncarpeted) surfaces.

** Significant at the 0.01 level.

All correlation coefficients in Table I5-16 were significant at the 0.01 level, regardless of whether data for carpeted or uncarpeted floors were being considered. Thus, the extent that linear relationships are present among the log-transformed dust-lead levels of differing dust collection methods or between dust-lead loadings and dust-lead concentrations under a specific vacuum method was consistent for both carpeted surfaces and uncarpeted floors. In particular, for carpeted floors, all three methods were significantly positively correlated.

I5.3.3 Investigating the Relationship in Lead Loadings of Side-by-Side Dust Samples Collected by Different Methods

To determine how the dust-lead loading measurement at a given sampling area differs between dust collection methods, regression model (6) of Section I4.3.3 was fitted to the measured dust-lead loadings for individual samples collected in Rochester study housing units, with samples taken from the same room assumed to be from adjacent, side-by-side areas. The regression model predicted the dust-lead loading for a sample taken by a specified dust collection method (method A) as a function of the dust-lead loading for the adjacent sample taken by another collection method (method B), with separate model fits for carpeted floor data and uncarpeted floor data.

Table I5-17 contains the estimated intercept and slope parameters and their standard errors associated with predicting dust-lead loadings under method A given the dust-lead loadings under method B. This table indicates that, for both carpeted and uncarpeted floors and at the 0.05 level, the intercepts were significantly different from zero in all but two instances, and the slope estimates were always significantly different from one. Thus, based on analysis of data from the Rochester study, different dust collection methods tended to provide dust samples with quantitatively different lead loadings, regardless of floor surface type, even when the dust samples were collected from adjacent locations. The extent of these differences was a function of the magnitude of the measurements.

Table I5-17. Estimates of Intercept and Slope Parameters (and Their Standard Errors) When Fitting Regression Models to Rochester Study Data That Predict Floor Dust-Lead Loadings Under Dust Collection Method A From Loadings for an Adjacent Floor Area Collected Using Method B

Floor Surface Type	Dust-Lead Level to be Predicted (PbD - Method A)	Dust-Lead Predictor Variable (PbD - Method B)	Estimate (Standard Error)	
			Intercept (μ)	Slope (α)
Carpeted surfaces	BRM Loading	DVM Loading	4.81* (0.10)	0.347† (0.064)
	BRM Loading	Wipe Loading	4.52* (0.25)	0.303† (0.100)
	DVM Loading	Wipe Loading	0.164 (0.244)	0.444† (0.098)
	DVM Loading	BRM Loading	-0.585 (0.337)	0.343† (0.063)
	Wipe Loading	BRM Loading	1.70* (0.237)	0.133† (0.044)
	Wipe Loading	DVM Loading	2.16* (0.068)	0.191† (0.042)
Uncarpeted surfaces	BRM Loading	DVM Loading	2.46* (0.091)	0.454† (0.073)
	BRM Loading	Wipe Loading	0.870* (0.373)	0.557† (0.131)
	DVM Loading	Wipe Loading	-1.03* (0.338)	0.335† (0.118)
	DVM Loading	BRM Loading	-0.965* (0.162)	0.359† (0.058)
	Wipe Loading	BRM Loading	2.39* (0.099)	0.152† (0.036)
	Wipe Loading	DVM Loading	2.78* (0.052)	0.119† (0.042)

The regression model takes the form $\log(PbDA_{ij}) = \mu + \alpha(\log(PbDB_{ij})) + H_i + \epsilon_{ij}$, where subscript i corresponds to the ith housing unit, subscript j corresponds to the jth room within a housing unit, H_i refers to the random effect associated with the ith housing unit, ϵ_{ij} refers to the random effect representing within-unit variability and other random error, and remaining notation is specified in the column headings.

* Significantly different from zero at the 0.05 level (indicating results for one method are consistently higher or lower than results for the other method).

† Significantly different from one at the 0.05 level (indicating the magnitude of differences between the two methods is a function of the value of the predictor variable).

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APPENDIX I2

DESCRIPTIVE SUMMARIES OF DATA ENDPOINT VALUES UTILIZED IN THE CARPET DUST-LEAD DATA ANALYSIS OF APPENDIX I

APPENDIX I2
DESCRIPTIVE SUMMARIES OF DATA ENDPOINT VALUES UTILIZED IN THE CARPET DUST-LEAD DATA ANALYSIS OF APPENDIX I

In this appendix, data values for variables considered in the statistical analyses of Appendix I are summarized across housing units to provide important information when interpreting results of these analyses. Descriptive statistics such as the sample size (i.e., numbers of housing units), arithmetic and geometric means, standard deviation, geometric standard deviation, minimum, maximum, and selected percentiles were calculated for selected endpoints from each study. Descriptive statistics on dust-lead variables were calculated within the data categories noted in Table I3-1 of Section I3 (Appendix I). The percentage of floor-dust samples collected from carpeted floors within a housing unit was summarized across units to determine the extent to which dust-lead data from carpeted surfaces were available for these units. When summarizing blood-lead concentration data, the percentage of children with blood-lead concentrations at or above a specified threshold (10, 15, or 20 μg/dL) was also summarized.

Note that the summaries presented in this appendix may differ from similar summaries presented in previously-published documents on these studies. This is due to differences in the subsets of data included in the analysis and in any transformations and summary calculations performed on the data prior to analysis.

While the descriptive statistics were calculated across all surveyed housing units in each study, they were also calculated by grantee and by categories denoting the year in which the housing units were built (pre-1940, 1940-1959, 1960-1977, post-1977) for the HUD Grantees evaluation. As the specified year in which a housing unit was built may be unreliable in the Rochester study, summaries of Rochester study data (and any subsequent analyses of these data) did not consider age of housing unit.

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Area-weighted average floor dust-lead loadings and mass-weighted average floor dust-lead concentrations for the 205 housing units in the Rochester study are summarized in Tables I2-1 and I2-2, respectively, according to surface type (carpeted and uncarpeted floors) and dust collection method. As seen in these tables, not all units had dust-lead data available for a given dust collection method. The following conclusions can be made from these two tables:

- While carpeted floors had a substantially higher geometric mean average dust-lead loading relative to uncarpeted floors under the BRM (255 μg/ft^2 versus 17.5 μg/ft^2), this disparity was considerably less for the DVM (4.51 μg/ft^2 versus 1.28 μg/ft^2). In contrast, little, if any, difference between carpeted and uncarpeted floors was seen in the geometric mean under the wipe (12.5 μg/ft^2 for carpeted floors versus 18.0 μg/ft^2 for uncarpeted floors).

Table I2-1. Summary Statistics of Area-Weighted Average Floor Dust-Lead Loadings ($\mu g/ft^2$) Across Housing Units in the Rochester Study, According to Type of Surface and Dust Collection Method

Method	# Units	Arithmetic Mean (Std. Dev.)	Geometric Mean (Geometric Std. Dev.)	Minimum	25th Percentile	Median	75th Percentile	Maximum
Carpeted Floors								
BRM	179	1210 (4470)	255 (4.95)	8.27	82.7	266	627	47300
DVM	181	33.2 (212)	4.51 (4.81)	0.0500	1.90	4.18	9.18	2680
Wipe	179	141 (1340)	12.5 (3.09)	0.810	8.35	13.	19.1	17300
Uncarpeted Floors								
BRM	191	530 (5370)	17.5 (7.91)	0.0800	5.00	13.1	45.3	74100
DVM	194	10.6 (55.7)	1.28 (6.45)	0.0500	0.250	1.90	4.34	690
Wipe	193	134 (1310)	18.0 (3.12)	0.640	10.1	17.0	28.1	18100

Table I2-2. Summary Statistics of Mass-Weighted Average Floor Dust-Lead Concentrations ($\mu g/g$) Across Housing Units in the Rochester Study, According to Type of Surface and Dust Collection Method

Method	# Units	Arithmetic Mean (Std. Dev.)	Geometric Mean (Geometric Std. Dev.)	Minimum	25th Percentile	Median	75th Percentile	Maximum
Carpeted Floors								
BRM	178	500. (3040)	131 (4.81)	1.00	72.0	163	353	40600
DVM	177	1290 (9320)	148 (5.73)	1.00	78.2	164	381	119000
Uncarpeted Floors								
BRM	189	2310 (8800)	394 (6.44)	1.76	157	406	1200	92000
DVM	177	1240 (3890)	208 (7.61)	1.00	49.6	318	747	35800

- For carpeted floors, the geometric mean dust-lead loading for samples collected by the BRM was an order of magnitude higher than under the DVM and wipe methods. This result was not observed for uncarpeted floors. The geometric mean dust-lead loading using the DVM was slightly lower than for the wipe method for both surface types.

- Little difference was observed in geometric mean floor dust-lead concentrations between the BRM and DVM samplers.

- For both dust-lead loadings and concentrations, the arithmetic mean is considerably larger than the geometric mean and the 75th percentile, indicating skewness in the data distribution. This is evidence of the need to take a transformation of the data, such as a logarithmic transformation, prior to analysis.

Higher dust-lead loadings associated with the BRM on carpeted surfaces is primarily due to its high sampling velocity which removes a greater amount of the total dust (and lead) in the carpet relative to the DVM and the wipe, which tend to remove only surface dust.

Measured dust-lead loadings on carpeted floors can be affected by the height of the carpet pile, as dust can be more difficult to sample from high-piled carpet. Therefore, it would be of interest to summarize carpet dust-lead loadings according to high-piled carpet versus low-piled carpet within a housing unit. However, only 9% of the 1,263 carpet-dust samples collected in the Rochester study were from high-piled carpet. Of the 181 housing units in the Rochester study with carpet-dust sample results, 20 units had at least one dust sample taken from high-piled carpet and at least one from low-piled carpet. Of these units, only two units had more than one dust sample taken from high-piled carpet (both had two such samples collected). Therefore, a lack of data precluded a summary of carpet dust-lead measurements by carpet height.

Most of the carpet-dust samples in the Rochester study were collected from carpets rated as being in average or good condition. Only 33 of the 181 housing units with carpet-dust sample results had at least one such sample collected from a carpet in poor condition, with 15 of these units having all carpet-dust samples (up to three such samples per unit) taken from carpets in poor condition.

Area-weighted average dust-lead loadings on window sills were used as predictor variables for blood-lead concentration in the regression modeling analyses. Table I2-3 presents summaries of these endpoints by dust collection method. Although not used in the statistical analyses, area-weighted average dust-lead loadings on window wells and mass-weighted average dust-lead concentrations on window sills and window wells are also summarized in this table. These summaries indicate the following:

- Lead levels on window components tend to be very high in both studies (especially for window wells and when using BRM or wipe collection techniques)

Table I2-3. Summary Statistics of Weighted Average Dust-Lead Levels for Window Sills and Window Wells Across Housing Units in the Rochester Study, According to Dust Collection Method[1]

Method	# Units	Arithmetic Mean (Std. Dev.)	Geometric Mean (Geometric Std. Dev.)	Minimum	25th Percentile	Median	75th Percentile	Maximum
Window Sill Dust-Lead Loadings (µg/ft²)								
BRM	196	4750 (14100)	362 (10.4)	0.680	60.9	266	1610	11800
DVM	198	255 (1510)	27.1 (7.16)	0.266	9.06	32.5	80.5	20000
Wipe	196	586 (1460)	202 (3.97)	2.83	82.3	189	434	14900
Window Sill Dust-Lead Concentrations (µg/g)								
BRM	193	16800 (43500)	2960 (8.70)	3.15	1030	3200	13600	448000
DVM	192	3490 (9840)	722 (7.23)	0.750	222	941	2810	97800
Window Well Dust-Lead Loadings (µg/ft²)								
BRM	188	243000 (456000)	22700 (21.7)	6.86	1820	49800	285000	3030000
DVM	190	6110 (24600)	612 (11.9)	0.210	128	676	4450	303000
Wipe	189	39200 (93000)	4520 (10.7)	28.5	739	4810	25500	641000
Window Well Dust-Lead Concentrations (µg/g)								
BRM	186	35000 (43600)	8710 (10.8)	5.15	2140	19600	50400	207000
DVM	189	10500 (32300)	2230 (8.36)	0.00	550	3010	9860	41300

[1] In calculating weighted averages for each housing unit, loadings are weighted by area of sample, and concentrations are weighted by mass of sample.

- A logarithmic transformation should be applied to these data prior to their inclusion in any statistical analyses.

Table I2-4 presents data summaries for other continuous endpoints used in statistical analyses, such as average soil-lead concentration and the percentage of floor-dust sample area consisting of carpet. Although not used in the statistical analysis presented in Section I5, data on the 75th percentile of XRF measurements in a housing unit are also summarized in Table I2-4. Table I2-5 provides additional information on the percentage of floor-dust samples in a unit taken from carpet. These two tables indicate the following:

Table I2-4. Summary Statistics for Continuous Endpoints Other Than Dust-Lead Measurements, Across Housing Units in the Rochester Study

Endpoint	# Units	Arithmetic Mean (Std. Dev.)	Geometric Mean (Geometric Std. Dev.)	Minimum	25th Percentile	Median	75th Percentile	Maximum
% of Floor Sample Area from Carpet[1]	204	51.1 (26.8)	--	0	33.3	50	75	100
% of Carpeted Floor Sample Area from High-Pile Carpet[1]	181	9.6 (24.8)	--	0	0	0	0	100
Soil-lead concentration (fine fraction) (μg/g)	190	1120 (1360)	622 (3.36)	12.3	380.	751	1330	10700
75th percentile of interior XRF measurements (mg/cm²)[1]	204	1.88 (5.10)	--	0	0	0	1.35	28.4
75th percentile of exterior XRF measurements (mg/cm²)[2]	204	4.74 (8.04)	--	0	0	0	8.50	35.0
Blood-lead concentration (μg/dL)	204	7.70 (5.14)	6.37 (1.85)	1.40	4.20	6.10	9.70	31.7
Age of Child (years)	204	1.74 (0.44)	--	1.01	1.35	1.69	2.13	2.62
Cleaning Frequency	204	0.73 (0.16)	-	0.25	0.625	0.75	0.8125	1
Mouthing Behavior[3]	202	0.19 (0.14)	--	0	0.0625	0.1875	0.25	0.75

[1] Calculated without regard to dust collection method.

[2] XRF measurements less than 1.0 mg/cm² or corresponding to surfaces with intact paint were set to zero prior to determining this value. For this reason, geometric means were not calculated for this endpoint. The value of the interior measurement endpoint was zero for 72% of the units, while the value of the exterior measurement endpoint was zero for 61% of the units.

[3] One-sixteenth of the sum of the values assigned to the four variables denoting a child's frequency of putting mouth on window sill, pacifier in mouth, soil in mouth, or thumb in mouth. Each of these four variables have possible values of 0 (never), 1 (rarely), 2 (sometimes), 3 (often), or 4 (always).

Table I2-5. Numbers (and Percentages) of Housing Units in the Rochester Study With Specified Values for the Percentage of Total Sampled Floor Area from Carpet and the Percentage of Total Sampled Carpeted Floor Area from High-Pile Carpet

# of Units[1]	Percent of Total Sampled Floor Area Taken from Carpet						
	0%	Between 0% and (Including) 25%	Between 25% and 50%	50%	Between 50% and (Including) 75%	Between 75% and 100%	100%
204	23 (11.3%)	27 (13.2%)	9 (4.4%)	62 (30.4%)	61 (29.9%)	12 (5.9%)	10 (4.9%)
# of Units[1]	Percent of Total Carpeted Floor Area Taken from High-Pile Carpet						
	0%	Between 0% and (Including) 25%	Between 25% and 50%	50%	Between 50% and (Including) 75%	Between 75% and 100%	100%
181	153 (84.5%)	2 (1.1%)	2 (1.1%)	14 (7.7%)	2 (1.1%)	0 (0%)	8 (4.4%)

[1] Numbers of housing units having data for the given sample type.

- The observed distribution of average soil-lead concentration indicates that this variable should be log-transformed prior to inclusion in any statistical analyses.

- For both interior and exterior painted surfaces, over half of the housing units had at least 75 percent of its XRF paint measurements either 1) below 1.0 mg/cm^2 or 2) taken from a surface with intact paint.

- Housing units, on average, had 51% of its floor-dust samples taken from carpet (without regard to dust collection method), with the majority of housing units having from 50-75% of floor-dust samples taken from carpeted surfaces.

- As approximately 84% of the 181 units with carpet-dust sampling had no samples taken from high-pile carpets, carpet height provides little discerning information for statistical analysis and was therefore not considered in further analyses.

Lead-based paint hazard score, defined in Table I3-2 of Section I3, was used in the statistical analyses to indicate the extent to which deteriorated lead-based paint is present in a housing unit and that the monitored child in the unit exhibits pica tendencies. For the Rochester study, 188 housing units (92%) had a lead-based paint hazard score of 0, indicating that no deteriorated lead-based paint was present, or that the resident child exhibits no pica tendencies. Of the remaining 16 housing units, only five achieved the highest score of 2, indicating the presence of deteriorated lead-based paint and the resident child exhibits pica tendencies at least sometimes. Therefore, this score would not provide much predictive power in determining blood-lead concentration in a child.

The geometric mean blood-lead concentration data for 204 children in the Rochester study was 6.37 µg/dL (Table I2-4). Further investigation shows that 48 (23.5%) of the children had a blood-lead concentration at or above 10 µg/dL, while 16 (7.8%) were at or above 15 µg/dL, and 6 (2.9%) were at or above 20 µg/dL.

HUD GRANTEES PROGRAM EVALUATION

A total of 395 housing units across 13 grantees had data for both blood-lead concentration and floor dust-lead loading in the September 1997 database. All but three of these units were built prior to 1960, with 353 (89%) built prior to 1940 and 39 (10%) built from 1940-1959. Only one housing unit was built after 1977. The large number of older housing units reduces the usefulness of the year built categorization in predicting blood-lead concentration.

Table I2-6a summarizes area-weighted arithmetic average of (untransformed) floor dust-lead loadings according to surface type (carpeted and uncarpeted floors) and dust collection method (wipe, DVM). Tables I2-6b and I2-6c contain the same summary statistics as Table I2-6a, but presented by year in which the housing unit was built and grantee, respectively. Results from these three tables are as follows:

- The geometric mean wipe dust-lead loading across units was somewhat higher for uncarpeted floors (32.4 µg/ft^2 across 390 units) than for carpeted floors (17.1 µg/ft^2 across 226 units). For carpeted floors, the geometric mean DVM dust-lead loading in 24 units (9.43 µg/ft^2) averaged lower than the average wipe dust-lead loading in 226 units (17.1 µg/ft^2). These trends were similar to those seen in the Rochester data summary in Table I2-1.

- The grantees differ in the percentage of housing units having all floor dust-lead loading measurements reported at a constant value, suspected to be the detection limit divided by the square root of two. This percentage is as high as 85% for 20 Baltimore samples. This constant value also differs among the grantees.

- Arithmetic means are larger than the geometric means and medians, indicating right skewness in the data distribution. This finding, along with additional data investigation, led to the conclusion that a logarithmic transformation would be made to these data prior to each statistical analysis. The same conclusion was made for the Rochester study based on results in Table I2-1.

Table I2-6a. Summary Statistics of Area-Weighted Average Floor Dust-Lead Loadings ($\mu g/ft^2$) Across Housing Units in the HUD Grantees Program Evaluation, According to Type of Surface and Dust Collection Method

Dust Collection Method	# of Units	Area-Weighted Average Floor Dust-Lead Loadings ($\mu g/ft^2$)						
		Arithmetic Mean (Std. Dev.)	Geometric Mean (Geometric Std. Dev.)	Minimum	25th Percentile	Median	75th Percentile	Maximum
Carpeted Floors								
Wipe	226	62.7 (341.7)	17.1 (3.2)	1.06	10.0	15.9	25.0	4764.
DVM	24	40.3 (77.9)	9.43 (6.18)	0.707	1.94	10.2	31.0	350.
Uncarpeted Floors[1]								
Wipe	390	93.1 (249.1)	32.4 (3.6)	0.511	14.1	25.7	66.5	2600.

[1] Only wipe dust samples were collected from uncarpeted floors.

Table I2-6b. Summary Statistics of Area-Weighted Average Floor Dust-Lead Loadings ($\mu g/ft^2$) Across Housing Units in the HUD Grantees Program Evaluation, According to Type of Surface, Dust Collection Method, and Age of Housing Unit

Year that the Unit was Built	# of Units	Area-Weighted Average Floor Dust-Lead Loadings ($\mu g/ft^2$)						
		Arithmetic Mean (Std. Dev.)	Geometric Mean (Geometric Std. Dev.)	Minimum	25th Percentile	Median	75th Percentile	Maximum
Carpeted Wipe								
Prior to 1940	216	65.2 (349.4)	17.7 (3.3)	1.06	11.8	17.6	26.5	4764.
1940 - 1959	9	9.91 (5.34)	8.61 (1.78)	3.54	5.01	9.00	13.6	17.7
1960 - 1979	1	6.77 (–)	6.77 (–)	6.77	6.77	6.77	6.77	6.77
Carpeted DVM								
Prior to 1940	15	62.1 (92.7)	20.9 (5.7)	0.707	9.49	24.0	98.0	350.
1940 - 1959	9	4.09 (4.89)	2.50 (2.75)	0.707	1.41	2.28	5.00	16.0
Uncarpeted Wipe								
Prior to 1940	349	98.5 (261.3)	34.0 (3.6)	0.511	16.0	26.7	72.0	2600.
1940 - 1959	38	38.7 (57.9)	20.4 (2.9)	3.54	11.3	17.7	34.0	293.
1960 - 1979	2	16.9 (8.6)	15.7 (1.7)	10.8	10.8	16.9	22.9	22.9
After 1977	1	440. (–)	440. (–)	440.	440.	440.	440.	440.

Table I2-6c. Summary Statistics of Area-Weighted Average Floor Dust-Lead Loadings ($\mu g/ft^2$) Across Housing Units in the HUD Grantees Program Evaluation, According to Type of Surface, Dust Collection Method, and Grantee

Grantee	# of Units	Area-Weighted Average Floor Dust-Lead Loadings ($\mu g/ft^2$)							
		Arithmetic Mean (Std. Dev.)	Geometric Mean (Geometric Std. Dev.)	Minimum	25th Percentile	Median	75th Percentile	Maximum	Mode[1] (% of Units)
Carpeted Wipe									
Baltimore	20	21.1 (9.9)	19.9 (1.4)	17.7	17.7	17.7	17.7	58.0	17.7 (85.0%)
Boston	14	18.7 (20.0)	12.5 (2.5)	4.51	5.00	10.8	21.2	78.0	5.00 (28.6%)
California	10	11.8 (13.8)	7.70 (2.44)	3.54	3.54	5.00	13.6	46.8	3.54 (30.0%)
Cleveland	40	192. (758.)	26.8 (5.2)	3.54	10.5	18.6	67.2	4764.	14.1 (20.0%)
Massachusetts	25	45.6 (97.2)	14.8 (4.5)	1.06	6.30	12.5	40.0	481.	1.06 (8.0%)
Minnesota	70	21.3 (20.5)	18.2 (1.6)	14.1	14.1	14.1	17.7	153.	14.1 (51.4%)
Rhode Island	15	57.9 (88.5)	22.4 (4.0)	5.08	5.66	17.0	47.5	291.	5.66 (20.0%)
Wisconsin	5	8.51 (5.71)	6.99 (2.04)	3.54	3.54	6.20	14.4	14.9	–
Milwaukee	2	6.63 (2.31)	6.43 (1.43)	5.00	5.00	6.63	8.27	8.27	–
Chicago	7	16.7 (18.8)	11.3 (2.4)	5.30	5.30	8.50	22.2	57.0	5.30 (28.6%)
New York City	12	22.7 (35.0)	7.61 (4.73)	1.50	2.25	3.39	37.4	118.	1.50 (8.3%)
Vermont	6	295. (669.)	45.5 (5.9)	20.5	20.5	21.2	28.1	1660.	20.5 (33.3%)
Carpeted DVM									
Alameda County	15	45.7 (96.5)	5.92 (7.89)	0.707	1.41	2.28	24.0	350.	0.707 (13.3%)
California	3	9.22 (5.93)	8.11 (1.83)	5.00	5.00	6.67	16.0	16.0	–
Cleveland	2	56.1 (59.3)	37.2 (3.9)	14.1	14.1	56.1	98.0	98.0	–

Table I2-6c. (cont.)

Grantee	# of Units	Area-Weighted Average Floor Dust-Lead Loadings (µg/ft²)							
		Arithmetic Mean (Std. Dev.)	Geometric Mean (Geometric Std. Dev.)	Minimum	25th Percentile	Median	75th Percentile	Maximum	Mode[1] (% of Units)
Carpeted DVM (cont.)									
Minnesota	3	35.1 (28.1)	28.4 (2.2)	14.1	14.1	24.1	67.0	67.0	–
New York City	1	38.0 (–)	38.0 (–)	38.0	38.0	38.0	38.0	38.0	–
Uncarpeted Wipe									
Alameda County	31	50.6 (123.0)	15.9 (3.7)	3.54	7.07	10.3	28.5	640.	7.07 (19.4%)
Baltimore	48	58.5 (100.2)	32.6 (2.4)	17.7	17.7	19.6	41.0	545.	17.7 (50.0%)
Boston	30	137. (376.)	44.1 (3.5)	5.83	20.0	29.4	90.4	2045.	17.7 (13.3%)
California	17	16.9 (20.1)	10.8 (2.5)	3.54	5.00	10.2	20.2	84.4	5.00 (23.5%)
Cleveland	46	200. (372.)	70.4 (4.4)	3.54	26.1	64.7	165.	1864.	14.1 (6.52%)
Massachusetts	32	166. (470.)	37.6 (4.9)	4.50	10.6	33.6	103.	2600.	4.50 (3.1%)
Minnesota	94	74.8 (210.5)	33.0 (2.7)	14.1	16.1	24.1	53.5	1831.	14.1 (24.5%)
Rhode Island	29	72.7 (101.6)	37.0 (3.2)	5.66	16.4	40.3	72.2	440.	5.66 (10.3%)
Wisconsin	5	103. (104.)	40.6 (6.7)	3.54	7.90	116.	134.	255.	–
Milwaukee	2	11.4 (6.5)	10.4 (1.8)	6.77	6.77	11.4	16.0	16.0	–
Chicago	19	37.1 (55.6)	22.1 (2.5)	6.29	10.9	19.0	39.8	252.	6.28 (5.3%)
New York City	27	32.4 (36.0)	16.8 (3.7)	0.511	6.46	25.1	45.1	158.	0.511 (3.7%)
Vermont	10	178. (168.)	100. (4.)	20.5	21.2	133.	300.	448.	21.2 (20.0%)

[1] The mode is the most frequently reported value for area-weighted average floor dust-lead loadings (the lowest value if more than one mode exists) and is specified for grantees having data for more than five housing units. It likely represents the detection limit for the given grantee, divided by the square root of two.

The HUD Grantees program evaluation did not record information on the type of carpet (e.g., high-piled versus low-piled) but did report on the condition of sampled surfaces. Of the 585 dust samples that were collected from carpets by wipe methods and that had lead loading data, only 34 came from carpets reported to be in poor condition.

Table I2-7 presents data summaries for other environmental and demographic variables, some of which were included in the statistical analyses due to their likelihood of being associated with blood-lead concentration. These variables include area-weighted average window sill and window well dust-lead loadings, average soil-lead concentration (over dripline and play areas in the yard), 75th percentile of XRF paint-lead measurements (Section A.1), age of child at blood collection, household annual income, and child's mouthing behavior. Results in this table are the following:

- The geometric means (across housing units) of average dust-lead loadings on window sills and window wells and average soil-lead concentration were similar to or slightly higher than those in the Rochester study (Tables I2-3 and I2-4).

- As soil sampling was optional in this program, only 77 of the 395 housing units had soil-lead concentration data reported at both the dripline and play areas. Thus, attempting to control for effects of soil-lead concentration in the statistical analyses results in a substantial reduction in the available numbers of housing units with sufficient data.

- Age of the children at blood collection ranged from 7 months to 8 years, with an average (and median) of approximately three years. Thus, approximately half of the blood-lead concentration data are for children older than 1-2 years, which was the population of interest in the §403 risk analysis.

Lead-based paint hazard score, as defined in Table I3-2 of Section I3, indicates the extent to which deteriorated lead-based paint was present in a housing unit and that the monitored child placed non-food objects in his/her mouth. In the HUD Grantees program evaluation, nearly 60% of the housing units had the highest possible score of 2, indicating that deteriorated lead-based paint was present in the unit, and the monitored child put non-food objects in his/her mouth several times per day or more. In contrast, only 25% of the housing units had the lowest score of zero, indicating that either no deteriorated lead-based paint was present or the monitored child did not place non-food objects in his/her mouth. This is in contrast to the Rochester study, where 92% of housing units had a score of zero. As in the Rochester study, the lead-based paint hazard score was used in the analyses rather than a direct measure of lead levels in paint.

Blood-lead concentration data are summarized in Table I2-8 according to year in which the housing unit was built, grantee, and ownership status, as well as across all units. Among grantees, geometric mean blood-lead concentration was highest for Cleveland (13.9 µg/dL), and lowest for California (3.14 µg/dL). This disparity is primarily due to the different criteria that each grantee used to select housing units. To further illustrate differences in blood-lead

Table I2-7. Summary Statistics of Area-Weighted Average Window Sill and Window Well Dust-Lead Loadings (µg/ft²), Average Soil-lead Concentration (µg/g), 75th Percentile of XRF Paint Measurements (mg/cm²), Age of Child, Annual Household Income, and Mouthing Behavior for Housing Units and Children in the HUD Grantees Program Evaluation

Endpoint	# of Units	Arithmetic Mean (Std. Dev.)	Geometric Mean (Geometric Std. Dev.)	Minimum	25th Percentile	Median	75th Percentile	Maximum
Window Sill Dust-Lead Loading (µg/ft²)	394	2160. (7050.)	374. (6.)	7.85	93.2	352.	1168.	78400.
Window Well Dust-Lead Loading (µg/ft²)	354	26100. (49000.)	4690. (10.)	4.95	805.	6300.	31950.	621000.
Soil-Lead Concentration (µg/g)[1]	77	1690. (2000.)	979. (3.)	39.5	534.	1085.	1930.	12648.
75th Percentile of Interior Paint XRF Measurements (mg/cm²)[2]	379	2.72 (4.91)	–	0.0	0.0	0.0	3.60	26.0
75th Percentile of Exterior Paint XRF Measurements (mg/cm²)[2]	202	9.20 (9.44)	–	0.0	2.60	8.13	10.8	56.9
Age of Child at Blood Collection (years)	395	3.14 (1.51)	–	0.61	1.81	2.89	4.40	8.41
Annual Household Income ($)	393	18800. (14400.)	–	0.0	8814.	16000.	24000.	112500.
Mouthing Behavior[3]	395	0.58 (0.39)	–	0.0	0.25	0.50	1	1

[1] Average of dripline and play area soil-lead concentration.

[2] 75th percentile of XRF paint-lead measurements in each unit, with XRF measurement for a given surface reset to zero when the measurement is less than 1.0 mg/cm², or the measurement is greater than or equal to 1.0 mg/cm² but the paint on the surface was considered intact.

[3] One-fourth of the sum of values assigned to the two variables denoting the frequency of the child putting fingers in mouth and toys/other objects in mouth. Both variables have possible values of 0 (never or less than once per week), 1 (several times per week), or 2 (several times a day or more).

Table I2-8. Summary Statistics of Blood-Lead Concentration (μg/dL) Across Housing Units in the HUD Grantees Program Evaluation, by Age of Housing Unit, Grantee, and Ownership Status[1]

	# of Units	Blood-Lead Concentration (μg/dL)						
		Arithmetic Mean (Std. Dev.)	Geometric Mean (Geometric Std. Dev.)	Minimum	25th Percentile	Median	75th Percentile	Maximum
All Units	395	10.3 (7.8)	7.76 (2.23)	0.707	4.00	8.00	15.0	53.0
By Year in Which the Unit Was Built								
Prior to 1940	353	10.6 (7.90)	7.97 (2.21)	0.707	4.50	8.00	15.0	53.0
1940 - 1959	39	7.91 (6.00)	5.87 (2.27)	1.41	3.54	6.00	12.0	26.0
1960 - 1977	2	15.0 (12.7)	12.0 (2.67)	6.00	6.00	15.0	24.0	24.0
After 1977	1	11.0 (–)	11.0 (–)	11.0	11.0	11.0	11.0	11.0
By Grantee								
Alameda County	31	5.97 (5.50)	4.35 (2.20)	1.41	3.00	4.50	5.90	24.8
Baltimore	48	9.65 (6.26)	7.88 (1.94)	2.00	5.50	7.00	14.0	29.0
Boston	30	9.99 (5.72)	8.48 (1.81)	3.00	6.00	8.50	14.0	24.0
California	18	4.09 (3.29)	3.14 (2.08)	1.41	1.41	3.25	6.00	12.8
Cleveland	47	16.7 (9.99)	13.9 (1.9)	3.00	10.0	14.0	23.0	53.0
Mass-achusetts	33	9.96 (6.22)	8.17 (1.92)	3.00	4.00	9.00	16.0	27.0
Minnesota	94	11.0 (8.7)	7.72 (2.52)	0.707	4.00	8.00	15.0	37.0
Rhode Island	30	11.4 (7.2)	9.21 (2.04)	2.00	6.00	10.0	17.0	29.0
Wisconsin	5	8.68 (4.97)	7.72 (1.70)	4.00	6.00	8.00	8.40	17.0
Milwaukee	2	6.50 (0.71)	6.48 (1.12)	6.00	6.00	6.50	7.00	7.00
Chicago	19	12.0 (6.4)	10.5 (1.7)	3.00	8.00	11.0	14.0	28.0
New York City	27	5.37 (3.39)	4.77 (1.57)	2.00	4.00	5.00	5.00	19.0
Vermont	11	12.8 (4.4)	12.1 (1.5)	6.00	10.0	13.0	16.0	20.0
By Ownership Status								
Rent	193	10.7 (7.5)	8.30 (2.09)	1.00	4.90	9.00	15.2	37.0
Own	202	10.0 (8.0)	7.27 (2.35)	0.707	4.00	8.00	14.0	53.0

[1] Blood-lead data for only one child per housing unit were selected (see Section 3.2).

concentrations across grantees, Table I2-9 summarizes the frequency counts of children with blood-lead concentration at or above 10, 15, and 20 µg/dL according to grantee. For example, 79% of the 47 sampled children in Cleveland had blood-lead concentrations at or above 10 µg/dL, compared to a program-wide percentage of 44%.

Table I2-10 summarizes the percentage of total sampled floor area from carpeted surfaces under wipe collection methods by presenting numbers of units within specified ranges of percentages. Table I2-11 contains additional descriptive statistics on the percentage of total sampled floor area from carpeted samples. Information obtained from these two tables includes the following:

- A total of 169 of the 395 units did not sample from carpeted floors, while only 5 units sampled from exclusively carpeted floors.

- Carpet sampling was more prevalent for units built prior to 1940 (compared to units built from 1940 - 1959) and for the Cleveland grantee.

- On average, about 29% of floor areas sampled using wipes were carpeted across the 395 housing units.

Therefore, in general, the HUD Grantees program evaluation had fewer occurrences of floor-dust samples taken from carpeted surfaces compared to the Rochester study (Tables I2-4 and I2-5). In this analysis, percentage of floor-dust sampling from carpeted surfaces was used as a surrogate for the percentage of carpeting in a housing unit.

Table 12-9. Frequency Counts of Children in the HUD Grantees Program Evaluation with Blood-Lead Concentration Greater than or Equal to 10, 15 and 20 μg/dL, by Grantee and Across All Grantees[1]

Grantee	Number of Children			% of Children		
	≥ 10 μg/dL	≥ 15 μg/dL	≥ 20 μg/dL	≥ 10 μg/dL	≥ 15 μg/dL	≥ 20 μg/dL
Alameda County	6	4	1	19.4%	12.9%	3.2%
Baltimore	19	10	3	39.6%	20.8%	6.3%
Boston	13	7	2	43.3%	23.3%	6.7%
California	2	0	0	11.1%	0.0%	0.0%
Cleveland	37	23	15	78.7%	48.9%	31.9%
Massachusetts	15	10	2	45.5%	30.3%	6.1%
Minnesota	42	27	19	44.7%	28.7%	20.2%
Rhode Island	17	8	5	56.7%	26.7%	16.7%
Wisconsin	1	1	0	20.0%	20.0%	0.0%
Chicago	11	3	3	57.9%	15.8%	15.8%
New York City	2	1	0	7.4%	3.7%	0.0%
Vermont	9	5	1	81.8%	45.5%	9.1%
All Grantees	174	99	51	44.1%	25.1%	12.9%

[1] The frequency counts were based on 395 housing units (one child per housing unit). Total numbers of housing units within each grantee are found in Table 12-6.

Table 12-10. Percentage of Total Sampled Floor Area from Carpeted Surfaces under Wipe Collection Techniques for Housing Units in the HUD Grantees Program Evaluation, by Age of Housing Unit and by Grantee

	# of Units	Frequency Count of Percentage of Total Wipe Sampled Floor Area From Carpeted Surfaces (% of Total Units)						
		0%	Between 0% and (Including) 25%	Between 25% and 50%	50%	Between 50% and (Including) 75%	Between 75% and 100%	100%
All Units	395	169 (42.8%)	68 (17.2%)	36 (9.1%)	32 (8.1%)	57 (14.4%)	28 (7.1%)	5 (1.3%)
By Year in Which the Unit Was Built								
Prior to 1940	353	137 (38.8%)	66 (18.7%)	34 (9.6%)	30 (8.5%)	54 (15.3%)	28 (7.9%)	4 (1.1%)
1940 - 1959	39	30 (76.9%)	2 (5.1%)	2 (5.1%)	1 (2.6%)	3 (7.7%)	0 (0%)	1 (2.6%)

Table I2-10. (cont.)

	# of Units	Frequency Count of Percentage of Total Wipe Sampled Floor Area From Carpeted Surfaces (% of Total Units)						
		0%	Between 0% and (Including) 25%	Between 25% and 50%	50%	Between 50% and (Including) 75%	Between 75% and 100%	100%
By Year in Which the Unit Was Built (cont.)								
1960-1977	2	1 (50.0%)	0 (0%)	0 (0%)	1 (50.0%)	0 (0%)	0 (0%)	0 (0%)
After 1977	1	1 (100%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
By Grantee								
Alameda County	31	31 (100%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
Baltimore	48	28 (58.3%)	3 (6.3%)	2 (4.2%)	7 (14.6%)	7 (14.6%)	1 (2.1%)	0 (0%)
Boston	30	16 (53.3%)	7 (23.3%)	1 (3.3%)	2 (6.7%)	4 (13.3%)	0 (0%)	0 (0%)
California	18	8 (44.4%)	4 (22.2%)	2 (11.1%)	1 (5.6%)	2 (11.1%)	0 (0%)	1 (5.6%)
Cleveland	47	7 (14.9%)	7 (14.9%)	3 (6.4%)	6 (12.8%)	6 (12.8%)	17 (36.2%)	1 (2.1%)
Mass-achusetts	33	8 (24.2%)	11 (33.3%)	9 (27.3%)	0 (0%)	4 (12.1%)	0 (0%)	1 (3.0%)
Minnesota	94	24 (25.5%)	25 (26.6%)	11 (11.7%)	9 (9.6%)	20 (21.3%)	5 (5.3%)	0 (0%)
Rhode Island	30	15 (50.0%)	4 (13.3%)	4 (13.3%)	1 (3.3%)	4 (13.3%)	1 (3.3%)	1 (3.3%)
Wisconsin	5	0 (0%)	2 (40.0%)	0 (0%)	0 (0%)	3 (60.0%)	0 (0%)	0 (0%)
Milwaukee	2	0 (0%)	0 (0%)	0 (0%)	2 (100%)	0 (0%)	0 (0%)	0 (0%)
Chicago	19	12 (63.2%)	1 (5.3%)	2 (10.5%)	1 (5.3%)	2 (10.5%)	1 (5.3%)	0 (0%)
New York City	27	15 (55.6%)	2 (7.4%)	1 (3.7%)	2 (7.4%)	4 (14.8%)	3 (11.1%)	0 (0%)
Vermont	11	5 (45.5%)	2 (18.2%)	1 (9.1%)	1 (9.1%)	1 (9.1%)	0 (0%)	1 (9.1%)

Table I2-11. Summary Statistics of the Percentages of Total Sampled Floor Area from Carpeted Floors Across Housing Units in the HUD Grantees Program Evaluation, by Age of Housing Unit and by Grantee

	# of Units	Percentage of Total Sampled Floor Area from Carpeted Floors (%)					
		Arithmetic Mean (Std. Dev.)	Minimum	25th Percentile	Median	75th Percentile	Maximum
All Units, All Samples	395	31.6 (30.6)	0.0	0.0	25.0	60.0	100
All Units, Wipe Samples Only	395	28.6 (30.6)	0.0	0.0	24.7	50.0	100
By Year in Which the Unit Was Built (wipe samples only)							
Prior to 1940	353	30.5 (30.6)	0.0	0.0	25.0	50.0	100
1940 - 1959	39	12.2 (25.5)	0.0	0.0	0.0	0.0	100
1960 - 1979	2	25.0 (35.4)	0.0	0.0	25.0	50.0	50.0
After 1977	1	0.0 (–)	0.0	0.0	0.0	0.0	0.0
By Grantee (wipe samples only)							
Alameda County	31	0.0 (0)	0.0	0.0	0.0	0.0	0.0
Baltimore	48	22.2 (28.9)	0.0	0.0	0.0	50.0	80.0
Boston	30	19.8 (25.7)	0.0	0.0	0.0	25.0	75.0
California	18	26.1 (31.4)	0.0	0.0	20.0	40.0	100
Cleveland	47	54.1 (32.7)	0.0	25.0	60.0	85.7	100
Massachusetts	33	27.8 (24.8)	0.0	9.9	24.7	40.0	100
Minnesota	94	34.9 (28.0)	0.0	0.0	25.0	60.0	80.0
Rhode Island	30	22.7 (28.3)	0.0	0.0	4.4	41.7	100
Wisconsin	5	51.0 (26.8)	20.0	25.0	60.0	75.0	75.0
Milwaukee	2	50.0 (0)	50.0	50.0	50.0	50.0	50.0
Chicago	19	19.2 (28.6)	0.0	0.0	0.0	40.0	80.0
New York City	27	26.1 (33.2)	0.0	0.0	0.0	60.0	80.0
Vermont	11	26.8 (32.9)	0.0	0.0	20.0	50.0	100

APPENDIX J

ADDITIONAL PERFORMANCE CHARACTERISTICS ANALYSES, WHERE CANDIDATE STANDARDS FOR LEAD IN PLAY-AREA SOILS ARE CONSIDERED

Additional Performance Characteristics Analyses, Where Candidate Standards for Lead in Play-Area Soils Are Considered

Note: *This appendix was not included in the version of this report that EPA distributed for external peer review.*

This appendix is an extension to the performance characteristics analyses presented in Section 6.1. As discussed in Section 6.1, EPA employed performance characteristics analysis as a non-modeling approach to evaluating candidate §403 standards relative to their ability to detect lead hazards in homes containing children with elevated blood-lead concentrations.

The performance characteristics analyses in Section 6.1 evaluated candidate standards for dust-lead loadings on uncarpeted floors and window sills, yard-wide average soil-lead concentration, and the extent of deteriorated lead-based paint. After these analyses were completed and documented in this report, EPA wished to evaluate candidate soil-lead concentration standards that distinguished between areas of the yard where children played and other areas of the yard. Therefore, the performance analysis approach in Section 6.1 was repeated on data from the Rochester Lead-in-Dust study, where separate standards were considered for soil in play areas and soil in other areas of the yard. The results of these analyses are presented in this appendix.

According to the soil sampling protocol developed for the Rochester Lead-in-Dust study, a composite soil sample was to be collected within at least two feet of the foundation at each housing unit participating in the study. Then, a second composite soil sample was to be collected from bare areas of the yard where it could be determined that a resident child frequently played. Therefore, the Rochester study database distinguished between soil-lead concentrations collected from play areas and along the foundation.

As seen in Table 3-36 of the §403 risk analysis report, play area soil-lead concentration was specified for only 77 of the 205 housing units in the Rochester study. However, the soil sampling protocol for this study implied that play area soil samples were collected only when such areas contained bare soil. Therefore, the performance characteristics analyses presented in this appendix assumed that homes containing no data for play area soil-lead concentration had no bare soil in play areas, and therefore, the play area soil-lead concentration for these homes was assumed to be 0 ppm.

In this analysis, for a given housing unit in the Rochester study, the soil-lead concentration in areas of the yard other than play areas was equivalent to the yard-wide average soil-lead concentration calculated for the analyses presented within Section 6.1. For a given housing unit, this value was equal to the following:

- the average of play area and foundation soil-lead concentrations, if both were reported

- the play area soil-lead concentration, if it was reported but the foundation soil-lead concentration was not (assumes that no bare soil existed along the foundation)

- the foundation soil-lead concentration, if it was reported but the play area soil-lead concentration was not (assumes that no bare soil existed in play areas)

- 0 ppm, if neither the play area nor the foundation soil-lead concentrations were reported (assumes that no bare soil was available anywhere in the yard).

The performance characteristics analyses presented in this appendix consist of calculating estimates of sensitivity, specificity, positive predictive value, and negative predictive value, as they were defined within Section 6.1. In particular, sensitivity represents the number of homes with children having elevated blood-lead concentrations (i.e., blood-lead concentrations at or above 10 µg/dL) that exceed at least one candidate standard. Also, 100% minus the negative predictive value represents the percentage of homes at or above at least one standard that contain children with elevated blood-lead concentrations.

Table J-1 contains results of performance characteristics analyses performed under the following candidate standards:

- Uncarpeted floor dust-lead loading: 10, 20, 25, 40, 50, 100 µg/ft^2
- Window sill dust-lead loading: 250 µg/ft^2
- Play area soil-lead concentration: 250, 400, 1200, 2000 ppm
- Soil-lead concentration in non-play areas (see above): 400, 1200, 2000, 3000, 4000, 5000 ppm.

In addition, Table J-1 considers candidate play area soil-lead concentration standards of 100, 250, 400, 800, 1000, 1200, 2000, and 5000 ppm in situations where a play area soil-lead standard is the only standard being considered (i.e., no other dust or soil standards are considered). Note that the analyses within Table J-1 do not consider whether deteriorated lead-based paint is present in the housing units.

Results in Table J-1 show that when the only standard being considered is for play area soil-lead, the likelihood of having homes with elevated blood-lead levels that are at or above the candidate standard is quite low, even when the candidate standard is low. In turn, the likelihood of having elevated blood-lead children in homes that do not exceed the candidate standard is quite high. This is evidence that the other dust-lead and/or soil-lead standards should be considered simultaneously with the play area soil-lead standard in order to achieve desired goals for detecting homes with children having elevated blood-lead concentration.

Table J-1. Results of Performance Characteristics Analysis Performed on Data for Housing Units in the Rochester Lead-in-Dust Study, for Specified Sets of Candidate Standards for Lead in Floor Dust, Window Sill Dust, Soil in Play Areas, and Soil in Non-Play Areas

Note: Houses in the Rochester study with no play area soil-lead concentration specified were assumed to have no bare soil present in play areas, and therefore, their play area soil-lead concentration values were set to 0 ppm in this analysis. Non-play area soil-lead is specified if either dripline or play area soil-lead is nonzero or if no visible soil is present (when it is set to 0 ppm).

EBL = elevated blood-lead (≥ 10 μg/dL). LBP = Lead-based paint.

Set of Candidate Standards for Lead in ...				# Units At or Above At Least One Standard /Total # Units[1]	Performance Characteristics			
Play Area Soil (ppm)	Non-Play Area Soil (ppm)	Window Sill Dust (μg/ft²)	Uncarpeted Floor Dust (μg/ft²)		Sensitivity # (%) of Units with EBL Children That Are At or Above At Least One Standard[2]	Specificity # (%) of Units with No EBL Children That Are At or Above No Standard[3]	PPV # (%) of Units At or Above At Least One Standard That Have EBL Children[4]	NPV # (%) of Units At or Above No Standard That Do Not Have EBL Children[5]
5000				1/205	0/48 (0.0%)	156/157 (99.4%)	0/1 (0.0%)	156/204 (76.5%)
2000				2/205	1/48 (2.1%)	156/157 (99.4%)	1/2 (50.0%)	156/203 (76.8%)
1200				6/205	4/48 (8.3%)	155/157 (98.7%)	4/6 (66.7%)	155/199 (77.9%)
1000				7/205	4/48 (8.3%)	154/157 (98.1%)	4/7 (57.1%)	154/198 (77.8%)
800				12/205	5/48 (10.4%)	150/157 (95.5%)	5/12 (41.7%)	150/193 (77.7%)
400				31/205	7/48 (14.6%)	133/157 (84.7%)	7/31 (22.6%)	133/174 (76.4%)
250				48/205	11/48 (22.9%)	120/157 (76.4%)	11/48 (22.9%)	120/157 (76.4%)
100				72/205	15/48 (31.3%)	100/157 (63.7%)	15/72 (20.8%)	100/133 (75.2%)
2000	5000	250	100	72/185	26/44 (59.1%)	95/141 (67.4%)	26/72 (36.1%)	95/113 (84.1%)
2000	5000	250	50	76/185	28/44 (63.6%)	93/141 (66.0%)	28/76 (36.8%)	93/109 (85.3%)
2000	5000	250	40	81/185	31/44 (70.5%)	91/141 (64.5%)	31/81 (38.3%)	91/104 (87.5%)
2000	5000	250	25	93/185	34/44 (77.3%)	82/141 (58.2%)	34/93 (36.6%)	82/92 (89.1%)
2000	5000	250	20	106/185	36/44 (81.8%)	71/141 (50.4%)	36/106 (34.0%)	71/79 (89.9%)
2000	5000	250	10	148/185	43/44 (97.7%)	36/141 (25.5%)	43/148 (29.1%)	36/37 (97.3%)
1200	5000	250	100	74/185	28/44 (63.6%)	95/141 (67.4%)	28/74 (37.8%)	95/111 (85.6%)
1200	5000	250	50	78/185	30/44 (68.2%)	93/141 (66.0%)	30/78 (38.5%)	93/107 (86.9%)
1200	5000	250	40	83/185	33/44 (75.0%)	91/141 (64.5%)	33/83 (39.8%)	91/102 (89.2%)
1200	5000	250	25	94/185	35/44 (79.5%)	82/141 (58.2%)	35/94 (37.2%)	82/91 (90.1%)
1200	5000	250	20	107/185	37/44 (84.1%)	71/141 (50.4%)	37/107 (34.6%)	71/78 (91.0%)
1200	5000	250	10	148/185	43/44 (97.7%)	36/141 (25.5%)	43/148 (29.1%)	36/37 (97.3%)

Table J-1. (cont.)

Set of Candidate Standards for Lead in ...				# Units At or Above At Least One Standard /Total # Units[1]	Performance Characteristics			
Play Area Soil (ppm)	Non-Play Area Soil (ppm)	Window Sill Dust (µg/ft²)	Uncarpeted Floor Dust (µg/ft²)		Sensitivity # (%) of Units with EBL Children That Are At or Above At Least One Standard[2]	Specificity # (%) of Units with No EBL Children That Are At or Above No Standard[3]	PPV # (%) of Units At or Above At Least One Standard That Have EBL Children[4]	NPV # (%) of Units At or Above No Standard That Do Not Have EBL Children[5]
400	5000	250	100	88/185	28/44 (63.6%)	81/141 (57.4%)	28/88 (31.8%)	81/97 (83.5%)
400	5000	250	50	92/185	30/44 (68.2%)	79/141 (56.0%)	30/92 (32.6%)	79/93 (84.9%)
400	5000	250	40	97/185	33/44 (75.0%)	77/141 (54.6%)	33/97 (34.0%)	77/88 (87.5%)
400	5000	250	25	106/185	35/44 (79.5%)	70/141 (49.6%)	35/106 (33.0%)	70/79 (88.6%)
400	5000	250	20	119/185	37/44 (84.1%)	59/141 (41.8%)	37/119 (31.1%)	59/66 (89.4%)
400	5000	250	10	155/185	43/44 (97.7%)	29/141 (20.6%)	43/155 (27.7%)	29/30 (96.7%)
250	5000	250	100	94/185	28/44 (63.6%)	75/141 (53.2%)	28/94 (29.8%)	75/91 (82.4%)
250	5000	250	50	98/185	30/44 (68.2%)	73/141 (51.8%)	30/98 (30.6%)	73/87 (83.9%)
250	5000	250	40	103/185	33/44 (75.0%)	71/141 (50.4%)	33/103 (32.0%)	71/82 (86.6%)
250	5000	250	25	110/185	35/44 (79.5%)	66/141 (46.8%)	35/110 (31.8%)	66/75 (88.0%)
250	5000	250	20	123/185	37/44 (84.1%)	55/141 (39.0%)	37/123 (30.1%)	55/62 (88.7%)
250	5000	250	10	156/185	43/44 (97.7%)	28/141 (19.9%)	43/156 (27.6%)	28/29 (96.6%)
2000	4000	250	100	72/185	26/44 (59.1%)	95/141 (67.4%)	26/72 (36.1%)	95/113 (84.1%)
2000	4000	250	50	76/185	28/44 (63.6%)	93/141 (66.0%)	28/76 (36.8%)	93/109 (85.3%)
2000	4000	250	40	81/185	31/44 (70.5%)	91/141 (64.5%)	31/81 (38.3%)	91/104 (87.5%)
2000	4000	250	25	93/185	34/44 (77.3%)	82/141 (58.2%)	34/93 (36.6%)	82/92 (89.1%)
2000	4000	250	20	106/185	36/44 (81.8%)	71/141 (50.4%)	36/106 (34.0%)	71/79 (89.9%)
2000	4000	250	10	148/185	43/44 (97.7%)	36/141 (25.5%)	43/148 (29.1%)	36/37 (97.3%)
1200	4000	250	100	74/185	28/44 (63.6%)	95/141 (67.4%)	28/74 (37.8%)	95/111 (85.6%)
1200	4000	250	50	78/185	30/44 (68.2%)	93/141 (66.0%)	30/78 (38.5%)	93/107 (86.9%)
1200	4000	250	40	83/185	33/44 (75.0%)	91/141 (64.5%)	33/83 (39.8%)	91/102 (89.2%)
1200	4000	250	25	94/185	35/44 (79.5%)	82/141 (58.2%)	35/94 (37.2%)	82/91 (90.1%)
1200	4000	250	20	107/185	37/44 (84.1%)	71/141 (50.4%)	37/107 (34.6%)	71/78 (91.0%)
1200	4000	250	10	148/185	43/44 (97.7%)	36/141 (25.5%)	43/148 (29.1%)	36/37 (97.3%)
400	4000	250	100	88/185	28/44 (63.6%)	81/141 (57.4%)	28/88 (31.8%)	81/97 (83.5%)
400	4000	250	50	92/185	30/44 (68.2%)	79/141 (56.0%)	30/92 (32.6%)	79/93 (84.9%)
400	4000	250	40	97/185	33/44 (75.0%)	77/141 (54.6%)	33/97 (34.0%)	77/88 (87.5%)
400	4000	250	25	106/185	35/44 (79.5%)	70/141 (49.6%)	35/106 (33.0%)	70/79 (88.6%)
400	4000	250	20	119/185	37/44 (84.1%)	59/141 (41.8%)	37/119 (31.1%)	59/66 (89.4%)
400	4000	250	10	155/185	43/44 (97.7%)	29/141 (20.6%)	43/155 (27.7%)	29/30 (96.7%)

Table J-1. (cont.)

Set of Candidate Standards for Lead in —				# Units At or Above At Least One Standard /Total # Units[1]	Performance Characteristics			
Play Area Soil (ppm)	Non-Play Area Soil (ppm)	Window Sill Dust ($\mu g/ft^2$)	Uncarpeted Floor Dust ($\mu g/ft^2$)		Sensitivity # (%) of Units with EBL Children That Are At or Above At Least One Standard[2]	Specificity # (%) of Units with No EBL Children That Are At or Above No Standard[3]	PPV # (%) of Units At or Above At Least One Standard That Have EBL Children[4]	NPV # (%) of Units At or Above No Standard That Do Not Have EBL Children[5]
250	4000	250	100	94/185	28/44 (63.6%)	75/141 (53.2%)	28/94 (29.8%)	75/91 (82.4%)
250	4000	250	50	98/185	30/44 (68.2%)	73/141 (51.8%)	30/98 (30.6%)	73/87 (83.9%)
250	4000	250	40	103/185	33/44 (75.0%)	71/141 (50.4%)	33/103 (32.0%)	71/82 (86.6%)
250	4000	250	25	110/185	35/44 (79.5%)	66/141 (46.8%)	35/110 (31.8%)	66/75 (88.0%)
250	4000	250	20	123/185	37/44 (84.1%)	55/141 (39.0%)	37/123 (30.1%)	55/62 (88.7%)
250	4000	250	10	156/185	43/44 (97.7%)	28/141 (19.9%)	43/156 (27.6%)	28/29 (96.6%)
2000	3000	250	100	75/185	26/44 (59.1%)	92/141 (65.2%)	26/75 (34.7%)	92/110 (83.6%)
2000	3000	250	50	79/185	28/44 (63.6%)	90/141 (63.8%)	28/79 (35.4%)	90/106 (84.9%)
2000	3000	250	40	84/185	31/44 (70.5%)	88/141 (62.4%)	31/84 (36.9%)	88/101 (87.1%)
2000	3000	250	25	95/185	34/44 (77.3%)	80/141 (56.7%)	34/95 (35.8%)	80/90 (88.9%)
2000	3000	250	20	108/185	36/44 (81.8%)	69/141 (48.9%)	36/108 (33.3%)	69/77 (89.6%)
2000	3000	250	10	149/185	43/44 (97.7%)	35/141 (24.8%)	43/149 (28.9%)	35/36 (97.2%)
1200	3000	250	100	77/185	28/44 (63.6%)	92/141 (65.2%)	28/77 (36.4%)	92/108 (85.2%)
1200	3000	250	50	81/185	30/44 (68.2%)	90/141 (63.8%)	30/81 (37.0%)	90/104 (86.5%)
1200	3000	250	40	86/185	33/44 (75.0%)	88/141 (62.4%)	33/86 (38.4%)	88/99 (88.9%)
1200	3000	250	25	96/185	35/44 (79.5%)	80/141 (56.7%)	35/96 (36.5%)	80/89 (89.9%)
1200	3000	250	20	109/185	37/44 (84.1%)	69/141 (48.9%)	37/109 (33.9%)	69/76 (90.8%)
1200	3000	250	10	149/185	43/44 (97.7%)	35/141 (24.8%)	43/149 (28.9%)	35/36 (97.2%)
400	3000	250	100	90/185	28/44 (63.6%)	79/141 (56.0%)	28/90 (31.1%)	79/95 (83.2%)
400	3000	250	50	94/185	30/44 (68.2%)	77/141 (54.6%)	30/94 (31.9%)	77/91 (84.6%)
400	3000	250	40	99/185	33/44 (75.0%)	75/141 (53.2%)	33/99 (33.3%)	75/86 (87.2%)
400	3000	250	25	108/185	35/44 (79.5%)	68/141 (48.2%)	35/108 (32.4%)	68/77 (88.3%)
400	3000	250	20	121/185	37/44 (84.1%)	57/141 (40.4%)	37/121 (30.6%)	57/64 (89.1%)
400	3000	250	10	156/185	43/44 (97.7%)	28/141 (19.9%)	43/156 (27.6%)	28/29 (96.6%)
250	3000	250	100	96/185	28/44 (63.6%)	73/141 (51.8%)	28/96 (29.2%)	73/89 (82.0%)
250	3000	250	50	100/185	30/44 (68.2%)	71/141 (50.4%)	30/100 (30.0%)	71/85 (83.5%)
250	3000	250	40	105/185	33/44 (75.0%)	69/141 (48.9%)	33/105 (31.4%)	69/80 (86.3%)
250	3000	250	25	112/185	35/44 (79.5%)	64/141 (45.4%)	35/112 (31.3%)	64/73 (87.7%)
250	3000	250	20	125/185	37/44 (84.1%)	53/141 (37.6%)	37/125 (29.6%)	53/60 (88.3%)
250	3000	250	10	157/185	43/44 (97.7%)	27/141 (19.1%)	43/157 (27.4%)	27/28 (96.4%)

Table J-1. (cont.)

Set of Candidate Standards for Lead in ...				# Units At or Above At Least One Standard /Total # Units[1]	Performance Characteristics			
Play Area Soil (ppm)	Non-Play Area Soil (ppm)	Window Sill Dust (µg/ft²)	Uncarpeted Floor Dust (µg/ft²)		Sensitivity # (%) of Units with EBL Children That Are At or Above At Least One Standard[2]	Specificity # (%) of Units with No EBL Children That Are At or Above No Standard[3]	PPV # (%) of Units At or Above At Least One Standard That Have EBL Children[4]	NPV # (%) of Units At or Above No Standard That Do Not Have EBL Children[5]
2000	2000	250	100	79/185	27/44 (61.4%)	89/141 (63.1%)	27/79 (34.2%)	89/106 (84.0%)
2000	2000	250	50	83/185	29/44 (65.9%)	87/141 (61.7%)	29/83 (34.9%)	87/102 (85.3%)
2000	2000	250	40	88/185	32/44 (72.7%)	85/141 (60.3%)	32/88 (36.4%)	85/97 (87.6%)
2000	2000	250	25	99/185	35/44 (79.5%)	77/141 (54.6%)	35/99 (35.4%)	77/86 (89.5%)
2000	2000	250	20	112/185	37/44 (84.1%)	66/141 (46.8%)	37/112 (33.0%)	66/73 (90.4%)
2000	2000	250	10	152/185	43/44 (97.7%)	32/141 (22.7%)	43/152 (28.3%)	32/33 (97.0%)
1200	2000	250	100	81/185	29/44 (65.9%)	89/141 (63.1%)	29/81 (35.8%)	89/104 (85.6%)
1200	2000	250	50	85/185	31/44 (70.5%)	87/141 (61.7%)	31/85 (36.5%)	87/100 (87.0%)
1200	2000	250	40	90/185	34/44 (77.3%)	85/141 (60.3%)	34/90 (37.8%)	85/95 (89.5%)
1200	2000	250	25	100/185	36/44 (81.8%)	77/141 (54.6%)	36/100 (36.0%)	77/85 (90.6%)
1200	2000	250	20	113/185	38/44 (86.4%)	66/141 (46.8%)	38/113 (33.6%)	66/72 (91.7%)
1200	2000	250	10	152/185	43/44 (97.7%)	32/141 (22.7%)	43/152 (28.3%)	32/33 (97.0%)
400	2000	250	100	92/185	29/44 (65.9%)	78/141 (55.3%)	29/92 (31.5%)	78/93 (83.9%)
400	2000	250	50	96/185	31/44 (70.5%)	76/141 (53.9%)	31/96 (32.3%)	76/89 (85.4%)
400	2000	250	40	101/185	34/44 (77.3%)	74/141 (52.5%)	34/101 (33.7%)	74/84 (88.1%)
400	2000	250	25	110/185	36/44 (81.8%)	67/141 (47.5%)	36/110 (32.7%)	67/75 (89.3%)
400	2000	250	20	123/185	38/44 (86.4%)	56/141 (39.7%)	38/123 (30.9%)	56/62 (90.3%)
400	2000	250	10	157/185	43/44 (97.7%)	27/141 (19.1%)	43/157 (27.4%)	27/28 (96.4%)
250	2000	250	100	98/185	29/44 (65.9%)	72/141 (51.1%)	29/98 (29.6%)	72/87 (82.8%)
250	2000	250	50	102/185	31/44 (70.5%)	70/141 (49.6%)	31/102 (30.4%)	70/83 (84.3%)
250	2000	250	40	107/185	34/44 (77.3%)	68/141 (48.2%)	34/107 (31.8%)	68/78 (87.2%)
250	2000	250	25	114/185	36/44 (81.8%)	63/141 (44.7%)	36/114 (31.6%)	63/71 (88.7%)
250	2000	250	20	127/185	38/44 (86.4%)	52/141 (36.9%)	38/127 (29.9%)	52/58 (89.7%)
250	2000	250	10	158/185	43/44 (97.7%)	26/141 (18.4%)	43/158 (27.2%)	26/27 (96.3%)
2000	1200	250	100	91/185	33/44 (75.0%)	83/141 (58.9%)	33/91 (36.3%)	83/94 (88.3%)
2000	1200	250	50	95/185	35/44 (79.5%)	81/141 (57.4%)	35/95 (36.8%)	81/90 (90.0%)
2000	1200	250	40	100/185	38/44 (86.4%)	79/141 (56.0%)	38/100 (38.0%)	79/85 (92.9%)
2000	1200	250	25	107/185	38/44 (86.4%)	72/141 (51.1%)	38/107 (35.5%)	72/78 (92.3%)
2000	1200	250	20	118/185	39/44 (88.6%)	62/141 (44.0%)	39/118 (33.1%)	62/67 (92.5%)
2000	1200	250	10	155/185	43/44 (97.7%)	29/141 (20.6%)	43/155 (27.7%)	29/30 (96.7%)

Table J-1. (cont.)

Set of Candidate Standards for Lead in:				# Units At or Above At Least One Standard: /Total # Units[1]	Performance Characteristics			
Play Area Soil (ppm)	Non-Play Area Soil (ppm)	Window Sill Dust ($\mu g/ft^2$)	Uncarpeted Floor Dust ($\mu g/ft^2$)		Sensitivity # (%) of Units with EBL Children That Are At or Above At Least One Standard[2]	Specificity # (%) of Units with No EBL Children That Are At or Above No Standard[3]	PPV # (%) of Units At or Above At Least One Standard That Have EBL Children[4]	NPV # (%) of Units At or Above No Standard That Do Not Have EBL Children[5]
1200	1200	250	100	91/185	33/44 (75.0%)	83/141 (58.9%)	33/91 (36.3%)	83/94 (88.3%)
1200	1200	250	50	95/185	35/44 (79.5%)	81/141 (57.4%)	35/95 (36.8%)	81/90 (90.0%)
1200	1200	250	40	100/185	38/44 (86.4%)	79/141 (56.0%)	38/100 (38.0%)	79/85 (92.9%)
1200	1200	250	25	107/185	38/44 (86.4%)	72/141 (51.1%)	38/107 (35.5%)	72/78 (92.3%)
1200	1200	250	20	118/185	39/44 (88.6%)	62/141 (44.0%)	39/118 (33.1%)	62/67 (92.5%)
1200	1200	250	10	155/185	43/44 (97.7%)	29/141 (20.6%)	43/155 (27.7%)	29/30 (96.7%)
400	1200	250	100	102/185	33/44 (75.0%)	72/141 (51.1%)	33/102 (32.4%)	72/83 (86.7%)
400	1200	250	50	106/185	35/44 (79.5%)	70/141 (49.6%)	35/106 (33.0%)	70/79 (88.6%)
400	1200	250	40	111/185	38/44 (86.4%)	68/141 (48.2%)	38/111 (34.2%)	68/74 (91.9%)
400	1200	250	25	117/185	38/44 (86.4%)	62/141 (44.0%)	38/117 (32.5%)	62/68 (91.2%)
400	1200	250	20	128/185	39/44 (88.6%)	52/141 (36.9%)	39/128 (30.5%)	52/57 (91.2%)
400	1200	250	10	160/185	43/44 (97.7%)	24/141 (17.0%)	43/160 (26.9%)	24/25 (96.0%)
250	1200	250	100	108/185	33/44 (75.0%)	66/141 (46.8%)	33/108 (30.6%)	66/77 (85.7%)
250	1200	250	50	112/185	35/44 (79.5%)	64/141 (45.4%)	35/112 (31.3%)	64/73 (87.7%)
250	1200	250	40	117/185	38/44 (86.4%)	62/141 (44.0%)	38/117 (32.5%)	62/68 (91.2%)
250	1200	250	25	121/185	38/44 (86.4%)	58/141 (41.1%)	38/121 (31.4%)	58/64 (90.6%)
250	1200	250	20	132/185	39/44 (88.6%)	48/141 (34.0%)	39/132 (29.5%)	48/53 (90.6%)
250	1200	250	10	161/185	43/44 (97.7%)	23/141 (16.3%)	43/161 (26.7%)	23/24 (95.8%)
2000	400	250	100	145/185	41/44 (93.2%)	37/141 (26.2%)	41/145 (28.3%)	37/40 (92.5%)
2000	400	250	50	145/185	41/44 (93.2%)	37/141 (26.2%)	41/145 (28.3%)	37/40 (92.5%)
2000	400	250	40	146/185	42/44 (95.5%)	37/141 (26.2%)	42/146 (28.8%)	37/39 (94.9%)
2000	400	250	25	147/185	42/44 (95.5%)	36/141 (25.5%)	42/147 (28.6%)	36/38 (94.7%)
2000	400	250	20	154/185	42/44 (95.5%)	29/141 (20.6%)	42/154 (27.3%)	29/31 (93.5%)
2000	400	250	10	170/185	43/44 (97.7%)	14/141 (9.9%)	43/170 (25.3%)	14/15 (93.3%)
1200	400	250	100	145/185	41/44 (93.2%)	37/141 (26.2%)	41/145 (28.3%)	37/40 (92.5%)
1200	400	250	50	145/185	41/44 (93.2%)	37/141 (26.2%)	41/145 (28.3%)	37/40 (92.5%)
1200	400	250	40	146/185	42/44 (95.5%)	37/141 (26.2%)	42/146 (28.8%)	37/39 (94.9%)
1200	400	250	25	147/185	42/44 (95.5%)	36/141 (25.5%)	42/147 (28.6%)	36/38 (94.7%)
1200	400	250	20	154/185	42/44 (95.5%)	29/141 (20.6%)	42/154 (27.3%)	29/31 (93.5%)
1200	400	250	10	170/185	43/44 (97.7%)	14/141 (9.9%)	43/170 (25.3%)	14/15 (93.3%)

Table J-1. (cont.)

Set of Candidate Standards for Lead in ...				# Units At or Above At Least One Standard /Total # Units[1]	Performance Characteristics			
Play Area Soil (ppm)	Non-Play Area Soil (ppm)	Window Sill Dust (µg/ft²)	Uncarpeted Floor Dust (µg/ft²)		Sensitivity # (%) of Units with EBL Children That Are At or Above At Least One Standard[2]	Specificity # (%) of Units with No EBL Children That Are At or Above No Standard[3]	PPV # (%) of Units At or Above At Least One Standard That Have EBL Children[4]	NPV # (%) of Units At or Above No Standard That Do Not Have EBL Children[5]
400	400	250	100	147/185	41/44 (93.2%)	35/141 (24.8%)	41/147 (27.9%)	35/38 (92.1%)
400	400	250	50	147/185	41/44 (93.2%)	35/141 (24.8%)	41/147 (27.9%)	35/38 (92.1%)
400	400	250	40	148/185	42/44 (95.5%)	35/141 (24.8%)	42/148 (28.4%)	35/37 (94.6%)
400	400	250	25	149/185	42/44 (95.5%)	34/141 (24.1%)	42/149 (28.2%)	34/36 (94.4%)
400	400	250	20	156/185	42/44 (95.5%)	27/141 (19.1%)	42/156 (26.9%)	27/29 (93.1%)
400	400	250	10	171/185	43/44 (97.7%)	13/141 (9.2%)	43/171 (25.1%)	13/14 (92.9%)
250	400	250	100	147/185	41/44 (93.2%)	35/141 (24.8%)	41/147 (27.9%)	35/38 (92.1%)
250	400	250	50	147/185	41/44 (93.2%)	35/141 (24.8%)	41/147 (27.9%)	35/38 (92.1%)
250	400	250	40	148/185	42/44 (95.5%)	35/141 (24.8%)	42/148 (28.4%)	35/37 (94.6%)
250	400	250	25	149/185	42/44 (95.5%)	34/141 (24.1%)	42/149 (28.2%)	34/36 (94.4%)
250	400	250	20	156/185	42/44 (95.5%)	27/141 (19.1%)	42/156 (26.9%)	27/29 (93.1%)
250	400	250	10	171/185	43/44 (97.7%)	13/141 (9.2%)	43/171 (25.1%)	13/14 (92.9%)

[1] Total number of units having available data that could be compared to all specified candidate standards.
[2] Cell entries are(number of homes at or above at least one standard that have EBL children)/ number of homes containing EBL children), followed by the corresponding percentage (in parentheses).
[3] Cell entries are (number of homes not at or above at least one standard that do not have EBL children)/(total number of homes not containing EBL children), followed by the corresponding percentage (in parentheses).
[4] Cell entries are (number of homes at or above at least one standard that have EBL children)/(total number of homes at or above at least one standard), followed by the corresponding percentage (in parentheses).
[5] Cell entries are (number of homes not at or above at least one standard that do not have EBL children)/(total number of homes not at or above any standard), followed by the corresponding percentage (in parentheses).

Table J-2 contains results of performance characteristics analyses performed under the following candidate standards:

- Uncarpeted floor dust-lead loading: 40, 50 $\mu g/ft^2$
- Window sill dust-lead loading: 250 $\mu g/ft^2$
- Play area soil-lead concentration: 400 ppm
- Soil-lead concentration in non-play areas: 400, 800, 1200, 1600, 2000, 3000 ppm.

Unlike Table J-1, Table J-2 (like Table 6-8 in Section 6.1 of the report) documents the extent of deteriorated lead-based paint that is present in housing units that contain an elevated blood-lead child but are not at or above at least one of the candidate dust or soil standards. This information suggests which of these housing units would possibly exceed a standard on the amount of deteriorated lead-based paint and which would not. (Recall that the information in the Rochester study database on amount of deteriorated lead-based paint was not in a format that allowed direct comparisons to candidate standards on deteriorated lead-based paint that were considered for the §403 rule, and as a result, deteriorated lead-based paint needed to be handled in this manner in the analysis.)

Note that Table J-2 differs from Table 6-8 of Section 6.1 in that candidate soil-lead standards exclusively for play areas has been added to the set of standards. For example, at a yardwide average soil-lead concentration standard of 1200 ppm, a window sill dust-lead standard of 250 $\mu g/ft^2$, and a floor dust-lead standard of 40 $\mu g/ft^2$, only 100 of 184 homes exceeded at least one of these standards (Table 6-8), compared to 111 homes when a play area soil standard of 400 ppm is added to these three standards (Table J-2; where the yardwide average soil-lead standard is interpreted as a non-play area soil-lead standard). However, among the 11 additional homes triggered when a play area soil standard of 400 ppm was added to these standards, none had elevated blood-lead children. That is, sensitivity was not affected in this instance when adding the play area standard, and negative predictive value decreased slightly (from 92.9% to 91.8%). If the yardwide average soil-lead standard is increased to 2000 ppm, an additional 13 homes are triggered when a play area soil-lead standard of 400 ppm is added (from 88 to 101 homes; Tables 6-8 and J-2). Of these 13 homes, 2 contain elevated blood-lead children.

Table J-2. Results of Performance Characteristics Analysis Performed on Data for Housing Units in the Rochester Lead-in-Dust Study, for Specified Sets of Candidate Standards for Lead in Dust and Soil

__Note__: Houses in the Rochester study with no play area soil-lead concentration specified were assumed to have no bare soil present in play areas, and therefore, their play area soil-lead concentration values were set to 0 ppm in this analysis. Non-play area soil-lead is specified if either dripline or play area soil-lead is nonzero or if no visible soil is present (when it is set to 0 ppm).

LBP = lead-based paint (≥ 1.0 mg/cm²); EBL = elevated blood-lead level (≥ 10 μg/dL)

"Deteriorated lead-based paint" on a tested surface implies >5% of the lead-based paint is peeling, cracking, worn, chalking, flaking, blistering, or otherwise separating from the substrate.

Set of Candidate Standards for Lead in ...[1]				# Units At or Above At Least One Standard /Total # Units[2]	Performance Characteristics				Sum of the 4 Performance Characteristics (%)	# Units with EBL Children That Are At or Above No Standard and Have No Deteriorated LBP	# Units with EBL Children That Are At or Above No Standard, Where the % of Tested Interior Paint Surfaces Having Deteriorated LBP equals? ...				# Units with EBL Children That Are At or Above No Standard, Where the % of Tested Exterior Paint Surfaces Having Deteriorated LBP equals? ...			
Play Area Soil (ppm)	Non-Play Area Soil (ppm)	Window Sill Dust (μg/ft²)	Floor Dust (μg/ft²)		Sensitivity # (%) of Units with EBL Children That Are At or Above At Least One Standard[3]	Specificity # (%) of Units with No EBL Children That Are At or Above No Standard[4]	PPV # (%) of Units At or Above At Least One Standard That Have EBL Children[5]	NPV # (%) of Units At or Above No Standard That Do Not Have EBL Children[6]			0%	10-30%	31-50%	> 50%	0%	20-50%	51-75%	> 75%
400	400	250	40	147/184	42/44 (95.5%)	35/140 (25.0%)	42/147 (28.6%)	35/37 (94.6%)	243.6	0	0	1	0	1	1	0	0	1
400	800	250	40	121/184	39/44 (88.6%)	58/140 (41.4%)	39/121 (32.2%)	58/63 (92.1%)	254.4	2	3	1	0	1	3	0	1	1
400	1200	250	40	111/184	38/44 (86.4%)	67/140 (47.9%)	38/111 (34.2%)	67/73 (91.8%)	260.2	2	3	1	1	1	4	0	1	1
400	1600	250	40	105/184	37/44 (84.1%)	72/140 (51.4%)	37/105 (35.2%)	72/79 (91.1%)	261.9	3	4	1	1	1	5	0	1	1
400	2000	250	40	101/184	34/44 (77.3%)	73/140 (52.1%)	34/101 (33.7%)	73/83 (88.0%)	251.0	3	5	2	2	1	6	1	1	2
400	3000	250	40	99/184	33/44 (75.0%)	74/140 (52.9%)	33/99 (33.3%)	74/85 (87.1%)	248.2	3	5	2	3	1	6	2	1	2

Table J-2. (cont.)

Set of Candidate Standards for Lead In ...[1]				# Units At or Above At Least One Standard /Total # Units[2]	Performance Characteristics				Sum of the 4 Performance Characteristics (%)	# Units with EBL Children That Are At or Above No Standard and Have No Deteriorated LBP	# Units with EBL Children That Are At or Above No Standard, Where the % of Tested Interior Paint Surfaces Having Deteriorated LBP equals[7] ...				# Units with EBL Children That Are At or Above No Standard, Where the % of Tested Exterior Paint Surfaces Having Deteriorated LBP equals[7] ...			
Play Area Soil (ppm)	Non-Play Area Soil (ppm)	Window Sill Dust ($\mu g/ft^2$)	Floor Dust ($\mu g/ft^2$)		Sensitivity # (%) of Units with EBL Children That Are At or Above At Least One Standard[3]	Specificity # (%) of Units with No EBL Children That Are At or Above No Standard[4]	PPV # (%) of Units At or Above At Least One Standard That Have EBL Children[5]	NPV # (%) of Units At or Above No Standard That Do Not Have EBL Children[6]			0%	10-30%	31-50%	> 50%	0%	20-50%	51-75%	> 75%
400	400	250	50	146/184	41/44 (93.2%)	35/140 (25.0%)	41/146 (28.1%)	35/38 (92.1%)	238.4	1	1	1	0	1	2	0	0	1
400	800	250	50	119/184	38/44 (86.4%)	59/140 (42.1%)	38/119 (31.9%)	59/65 (90.8%)	251.2	3	4	1	0	1	4	0	1	1
400	1200	250	50	106/184	35/44 (79.5%)	69/140 (49.3%)	35/106 (33.0%)	69/78 (88.5%)	250.3	3	5	1	1	2	6	1	1	1
400	1600	250	50	100/184	34/44 (77.3%)	74/140 (52.9%)	34/100 (34.0%)	74/84 (88.1%)	252.2	4	6	1	1	2	7	1	1	1
400	2000	250	50	96/184	31/44 (70.5%)	75/140 (53.6%)	31/96 (32.3%)	75/88 (85.2%)	241.5	4	7	2	2	2	8	2	1	2
400	3000	250	50	94/184	30/44 (68.2%)	76/140 (54.3%)	30/94 (31.9%)	76/90 (84.4%)	238.8	4	7	2	3	2	8	3	1	2

[1] The data compared to these standards are average (wipe) floor dust-lead loading, average (wipe) window sill dust-lead loading, play area soil-lead concentration, and average soil-lead concentration (across dripline and play areas, with only one of the two areas represented if no data existed for the other area). Units having no reported soil-lead concentration but with no bare soil reported were assumed to have soil-lead concentrations of 0 ppm. For units having no play area soil results, it was assumed that the homes had no bare soil in play areas from which to collect soil samples, and therefore, the play area soil-lead concentration was assumed to be 0 ppm (after the average soil-lead concentration was calculated).
[2] Total number of units having available data that could be compared to all specified candidate standards, as well as data on the percentage of tested interior lead-based paint that is deteriorated and the percentage of tested exterior lead-based paint that is deteriorated.
[3] Cell entries are(number of homes at or above at least one standard that have EBL children)/ number of homes containing EBL children), followed by the corresponding percentage (in parentheses).
[4] Cell entries are (number of homes not at or above at least one standard that do not have EBL children)/(total number of homes not containing EBL children), followed by the corresponding percentage (in parentheses).
[5] Cell entries are (number of homes at or above at least one standard that have EBL children)/(total number of homes at or above at least one standard), followed by the corresponding percentage (in parentheses).
[6] Cell entries are (number of homes not at or above at least one standard that do not have EBL children)/(total number of homes not at or above any standard), followed by the corresponding percentage (in parentheses).
[7] No housing units had between 0 and 10% deteriorated lead-based paint on interior tested surfaces or between 0 and 20% deteriorated lead-based paint on exterior tested surfaces.